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BRITISH
MANUFACTURING INDUSTRIES.

BRITISH

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WOOL, AND ITS APPLICATIONS,

BY PROF. ARCHER, F.R.S.E., Director of Edinburgh Museum of Science and Art.

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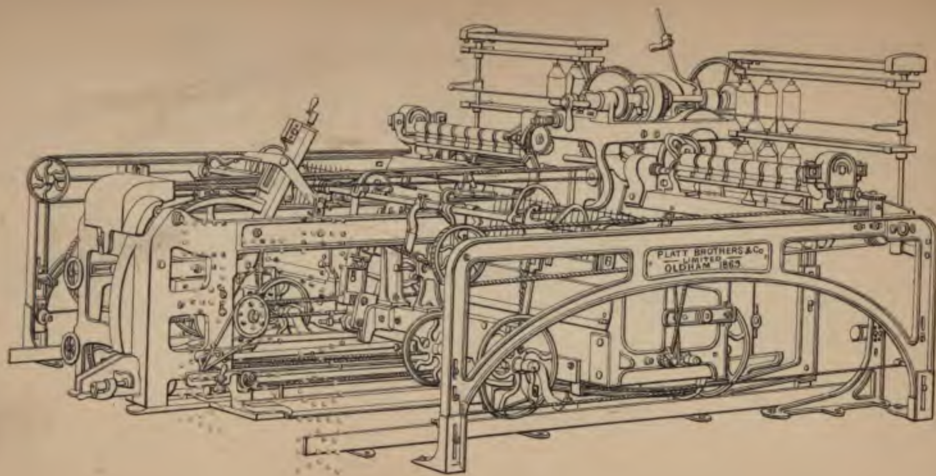

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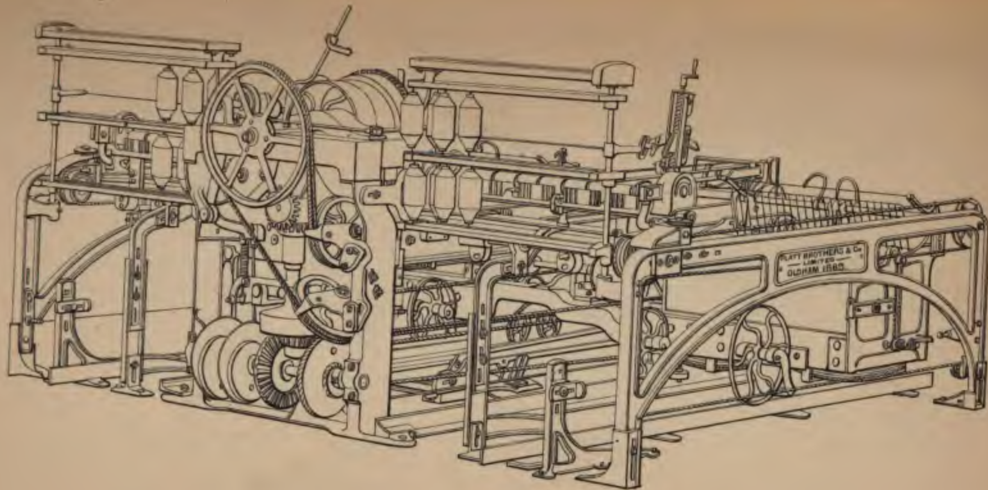

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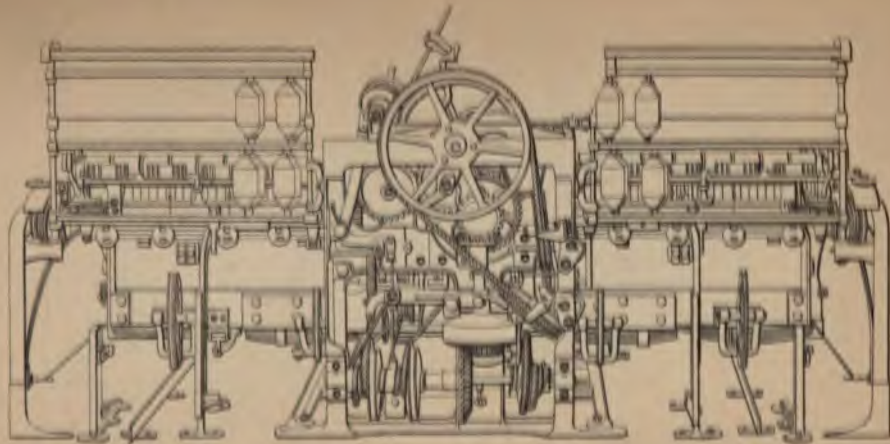

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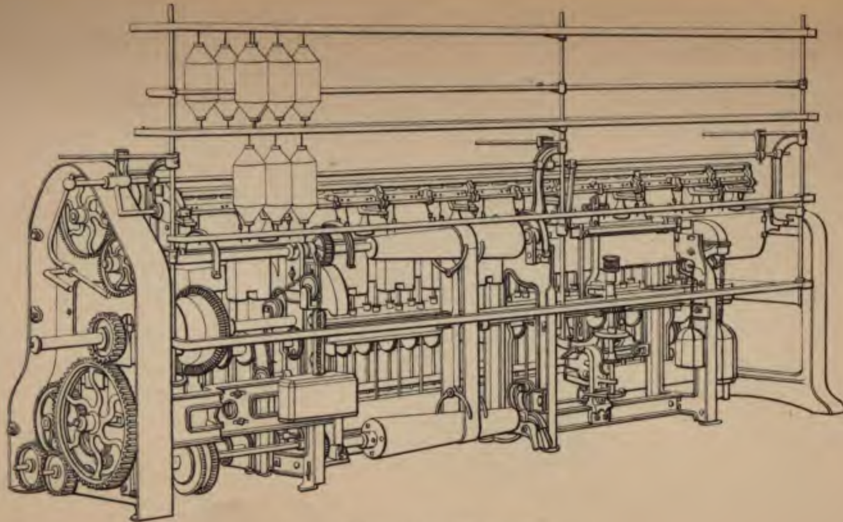

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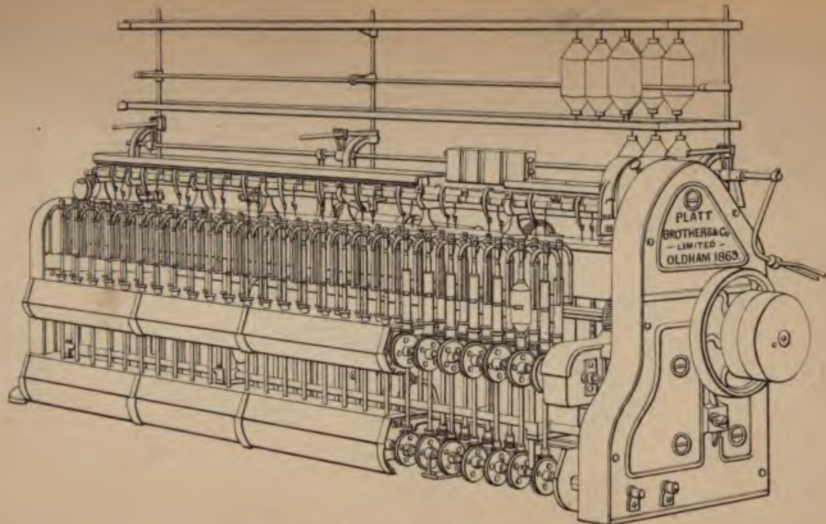

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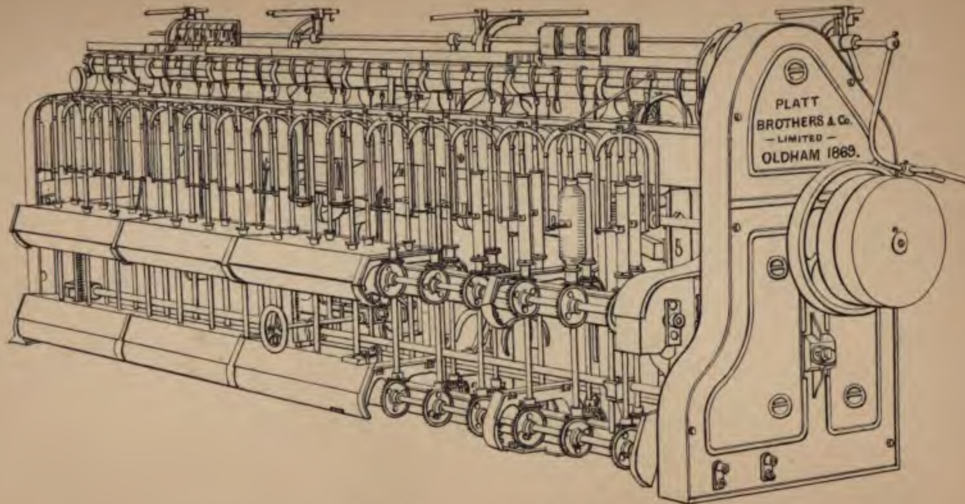

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PREFACE.

THE object of this series is to bring into one focus the leading features and present position of the most important industries of the kingdom, so as to enable the general reader to comprehend the enormous development that has taken place within the last twenty or thirty years. It is evident that the great increase in education throughout the country has tended largely to foster a simultaneous interest in technical knowledge, as evinced by the spread of Art and Science Schools, Trade Museums, International Exhibitions, &c.; and this fact is borne out by a perusal of the daily papers, in which the prominence given to every improvement in trade or machinery attests the desire of the reading public to know more about these matters. Here, however, the difficulty commences, for the only means of acquiring this information are from handbooks to the various manufactures (which are usually too minute in detail for general instruction), from trade journals and the reports of scientific societies; and to obtain and systematize these scattered details is a labour and a tax upon time and patience which comparatively few persons care to surmount. In these volumes all these facts are gathered together and presented in as readable a form as is compatible with accuracy and a freedom from superficiality; and though they do not lay claim to being a technical guide to each industry, the names of the contributors are a sufficient guarantee that they are a reliable and standard work of reference. Great stress is laid on the progressive developments of the manufactures, and the various applications to them of the collateral arts and sciences; the history of each is truly given, while present processes and recent inventions are succinctly described.

BRITISH MANUFACTURING INDUSTRIES.

WOOL, AND ITS APPLICATIONS.

By T. C. Archer, F.R.S.E., Director of the Edinburgh Museum of Science and Art.

By the term wool is generally understood that hairy covering of animals, which, besides being softer than the hair itself, has also a wavy character. Many of the mammalian animals have both wool and hair, but only in a very few is the wool in greater abundance than the hair proper. Chief of these is the sheep; next, the Angora goat; then the Llama, Alpaca, Vicugnia, and the camel.

The sheep has from the earliest historic times been of the highest importance to man as a wool-producer; nor can we limit its usefulness to the historic period, for prehistoric man was equally indebted to this useful animal; wherever we find the traces of his existence, there also we are almost sure to find the remains of sheep in the form of bones, and, in the instance of the lake-dwellers, fragments of woven woollen cloth.

The fact that the sheep has been so long domesticated, has caused it to be a matter of uncertainty whether it has been derived from any of the existing animals of the genus *Ovis.* Many have entertained the opinion that it is the same animal as the Argali, *Ovis Ammon*, Linn., a native of the mountains of Central Asia, and a great weight of evidence in favour of that supposition is obtained from the circumstance, that all the tribes of people who have from time immemorial dwelt on the plains surrounding those mountains have always been pastoral in their habits and occupations. Still, however, there is no positive proof that our sheep was derived either from the Argali or any other known wild species: and the probability has been much lessened by the recent discoveries of the remains of sheep, mingled with stone weapons of a people who existed under such different conditions of the earth's surface, that we may assume with as much probability that they were the progenitors of the Asiatics, as that the latter were their ancestors.

The very great antiquity of this friend of man is exceedingly interesting, and it would almost seem that it is essential to man's existence in temperate climates. This leads us very naturally to the question, "Why amongst all the numerous species of animals upon the earth's surface, does the sheep hold such pre-eminence?" Many reasons may be given in answer, but there is one which is the most important, and perhaps the only one which exists in greater perfection in the sheep than in any other known animal; and a knowledge of it is absolutely necessary to a correct understanding of its economic value for manufacturing purposes. It is the peculiar structure of the wool—a structure which makes it of use to the felt-maker spinner, and weaver. Valuable as the animal is in yielding wholesome food to man, that use is certainly secondary, and always has been, to its wool-producing powers. This important peculiarity in the structure of the wool can hardly be understood without the aid of illustrations, for it is to a great extent of a microscopic character. The best kind of wool for examination of its structure is that of the Merino sheep of fine quality, which will be seen to have a waved appearance (Fig. 1). If we remove a single hair and examine it, the unaided eye will enable us to perceive that this waviness of the whole lock depends upon a remarkably regular series of curves in each fibre of the lock (Fig. 2). Let us now place this individual

FIG. 1.

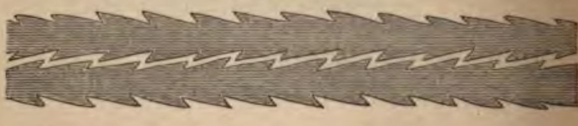
FIG. 2.

FIG. 3.

hair under a high power of the microscope, and we shall find that it is a cylinder, the surface of which is covered with imbricated scales pointing from the base upwards to the tip of the hair (Fig. 3). These scales are only *attached by* their bases to the cylindrical hair, for if we bend it (Fig. 4) we see that the scales are quite detached otherwise. With these facts and illustrations before us, it is plain that if two of these scaly cylinders are placed reversed ways—that is, the base of one to the top of the other, and *vice versâ*, and if they are brought into close contact and then pulled one against the other—the scales of the one hair are sure to slip into those of the other, in proportion to the force used in producing this intermingling. This

Fig. 4.

Fig. 5.



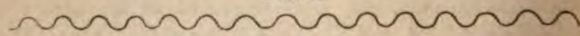
is shown in Fig. 5 diagramatically; but the fact is, the scales are relatively larger, more detached, and yet more closely laid on the cylinders; so that the point of one may become inserted under the point of the opposing scale, or it may be pressed down to the middle or to the bottom, according to the force used. At first sight these minute details may appear insignificant, but the reader will soon learn, that upon them depends everything of importance connected with the woollen and worsted manufactures; and these specialities in the structure of each individual fibre of wool have made the sheep the most valuable of all animals to man, not only in this advanced stage of his history, but even when he had to fight for the possession of his cave dwellings, with the cave bear, the hyena, and other fierce creatures, with no better weapons than he could fashion out of flints and stones.

We only know from the testimony of a few bones, found under special circumstances, that such was the case; but we have proofs in the historic records of later, though still very early periods, that the sheep and its wool were of the highest importance, and that the rearing of the animal, and the careful treatment of its valuable covering, were regarded as amongst the most useful of man's accomplishments. From the beginning of the Bible to its end we find continuous reference to these subjects; and our information from other archaic sources equally teems with allusions to pastoral life and to its importance. Only in Egypt, that land of wonders, of refined civilization, and of eminence in the technical manufactures, do we miss that of wool; it being evidently a part of its religion to eschew the use of sheep's wool, and to abominate the pastoral life. Possibly this arose out of political causes, such as repeated invasions by their pastoral neighbours, and the long and tyrannical dynasties of their occasional conquerors—the shepherd kings.

Whatever be the cause, the Egyptians disliked sheep's wool, and cultivated vegetable fibres, which with their fine and equable climate probably formed the better material for clothing. The perfection to which they brought the manufacture of their favourite material is well seen in the marvellous fabrics, which are found in such abundance in the receptacles of their dead.

The wool of a Merino sheep is recommended for microscopic examination, because in the class of short-staple wools to which it belongs, those peculiarities which have been described attain their perfection; the curves in the length, and the scales on the surface of each individual hair, being so much more numerous than on those of the long-stapled varieties, of which one is represented in Fig. 6. It will easily be under-

Fig. 6.



stood, that such fibres are admirably formed for spinning into a thread, because the curves of one fibre will fall into the others with which it is brought into contact without any bending, which must be the case if perfectly straight ones were twisted into a thread or yarn. The processes of preparing the wool for spinning consist chiefly in combing or carding the material, so as to lay the individual fibres side by side, by which operations they are placed variously as to their ends, the bases of some being in connection with the tips of others. Under these circumstances, the valuable little scales come into play, the points of one set becoming *inserted* under the points of another set, as in Fig. 5;

the fibres are closely interlocked, and form a thread which will not untwist. If we take any hair, say human hair, which has not these peculiarities, we may twist it as much as we like, but it will untwist again, owing to its elasticity and the want of the little scales to retain it in the twisted state.

Although, as a matter of course, these important points in the structure of wool have existed as long as the sheep has been known and man has availed himself of them, yet he has done so in blind ignorance of the facts until a very recent period. In 1853 Mr. Youatt, aided by Mr. Powell, the optician, examined the structure of Merino wool, and found that in the quality under his examination, there were no less than 2400 scales to an inch of fibre; this number is now nearly doubled in the wool of some of the rare races of Merinos, such as those raised in Bohemia and Hungary, and by the Grand Duchess Helene on her estates in Russia.

On examining other qualities, it will be found that the long and coarse staples are furnished with very much fewer scales, besides having longer curves, as in Fig. 6; e. g. a fibre of Leicester wool contains only about 1860 scales to an inch.

Although, as stated at the commencement of this paper, other animals besides sheep yield wool, yet the most careful examination has failed to discover that any other wool is so perfect in these two particulars; and if to this we add that none of the other wool-bearing animals possess the docility and capacity for domestication, the capability of bearing a great climatal range, and a special fitness for human food, all wonder ceases with respect to the fact, that the sheep has been the constant companion of man as far back as he himself can be traced. Perhaps man first used the skins of sheep for clothing; if so, the period was very remote indeed, for it has come to light within the last year or two that the curious bone combs so commonly found in the kitchen-middens and other deposits of the remains of prehistoric man, were more likely used for combing wool preparatory to spinning it, than for combing the hair of those who made them. Others have assumed that wool was first employed for clothing in the felted state, and not woven. That felted cloths were very early used by various nations is indisputable, and it is not to be wondered at that the curious property called felting was one of the first discoveries in the use of wool, for it occasionally, though rarely, becomes felted on the animal. This property is nothing more than the capability of the individual fibres to lock into each other as before described, without being twisted to produce the result. If a quantity of wool be spread in a layer, and wetted and beaten with a flat piece of wood, the fibres work together until they form a compact but much thinner layer, so much like cloth that it can be and is used as such. By this rude process, even in the present day, the peasantry of Northern Russia make thick felt shoes, boots, coats, hats, &c., which are warm and strong, though not very pliable, and of such materials the ancient Greeks made those classical hats that we see in their statues of gods and men, which but for a very slight difference in their form might be taken for the *jim-crows* of the present day. Still, however likely it was that the manufacture of felt was one of the earliest applications of wool, we must not forget, that the very oldest remains which have been discovered of woollen clothing have been fragments of *woven* cloths.

The greatest development of pastoral occupation, as far as we know, was in the neighbourhood of those mountains of Central Asia which are characterized by rich and fertile plains, a genial climate, and other conditions, as suitable to man as to his companion the sheep. As far back as our information goes, Mesopotamia, Persia, Syria, Arabia, Palestine, and Scythia have been famous. Then, as now, the shepherds wandered about with their flocks, seeking new pastures, and, we may presume, sold to the settled populations of the towns the produce of their husbandry in the form of wool, cheese, and milk. Throughout the Bible there is abundant evidence, that by the Hebrews and their neighbours the shepherds' employment was held to be most honourable as well as important; even royalty seemed to gain in esteem by adopting the care of flocks, as we read in 2 Kings iii. 4, "Mesha, King of Moab, was a sheep-master, and rendered unto the King of Israel an hundred thousand lambs, and an hundred thousand rams with the wool."

The Phœnicians were dealers in and manufacturers of wool, and attained great eminence in the art of dyeing it; the Tyrian purple, believed to be obtained from the animal of a sea-shell, *Murex truncatula*, is known to every classical scholar by the numerous allusions to its great repute amongst the ancients. The Greek colonies in Asia Minor gave an impetus to the manufacture of wool for ornamental as well as useful purposes, and the Ionian colony of Miletus was especially celebrated for its fine wool and its beautiful carpets; and both of these were probably at first obtained from the Coraxi, a native race who are supposed to be now represented by the Circassians. The Milesians then became so famous for their fine wool, that the palm was eventually conceded to them, and the Coraxi fell into the second rank. Still the latter retained pre-eminence for their shawls, which were so celebrated, that they are mentioned in a poem by Hipponax, of Ephesus, 540 B.C. It is, however, most likely that then, as now, the shawls of the ancestors of the Circassians, and probably too the carpets of Miletus, were made of goats' wool, which is the material of the Cashmerian shawls of modern times. This is the more likely, for some of the ancient authors likened the Milesian fleeces to the wool of the camel, and everyone who is familiar with the feeling of camel-hair or wool knows how strongly it resembles in that respect the wool of the Cashmere goat, of which the most beautiful shawls are made.

Like the Phœnicians, the Milesians also became very famous for their dyes; thus we find in Sotheby's translation of the third Georgiac of Virgil the following lines:

> "Let rich Miletus vaunt her fleecy pride,
> And weigh with gold her robes in purple dyed."

It is curious to look back to those times and compare them with the present. Then the most choice, the Milesian, fleeces were obtained from sheep which were covered with a coating of skin to protect the fleece, or rather to make it more attenuated in the fibres by the unusual care bestowed upon it. Nowadays the rare breeds of Moravia and other places are kept imprisoned in cots, which deprives the animal of all vigour, and makes each individual hair of the fleece partake of the general attenuation. Such rearing is too extravagant for general purposes, and is only another instance of the reckless cruelty too often resorted to for fostering luxury. Throughout the history of Greece and Rome, the culture of the sheep was second to no other occupation in importance, and was mixed up with their religion, their commerce, and indeed with all the relations of their life. Pastoral life was the favourite subject, after love, with their poets, and the favourite recreation of their great men, when seeking retirement from the cares of more active life. It cannot be said that in this respect matters are much changed, for in all parts of Europe where the animal thrives, the wealthy delight in owning large flocks and enjoying somewhat of an Arcadian life.

It is not within the limits of this article to enter upon the moot points connected with the question, whether the sheep is indigenous to, or imported into, Great Britain. Suffice it to say that there is no proof of its introduction, but there are proofs that it existed long antecedent to the Roman invasion and occupation. It is interesting, however, to know that our conquerors, amongst the many other lessons that they taught us, systematically manufactured wool first in Britain, at *Winchester; and* in the time of Dionysius Alexandrinus, a Roman author of that period, this manufactory had attained such celebrity abroad, that he thus writes, "The wool of Britain is often spun so fine, that it is in a manner comparable to the spider's thread."

Now the Romans were not likely to have brought wool to this country for the purpose of making it into cloth, and we must therefore conclude that they found it here in such abundance and of such good quality, as to tempt them to utilize it. How interesting would it be in this country, which of this material consumes annually more than 350,000,000 pounds, to learn all the particulars of that first establishment in our island, to know how it was managed and for whose behoof, how many workers it employed, and how they worked. What a striking contrast it would offer to those mighty hives of industry in busy Yorkshire, in which thousands of hands, and machines of wondrous complexity and power, produce fabrics at a rate which could not even have been imagined by the early founders of the trade. Equally interesting would it be, if we could learn how it throve, and whether any similar establishments were started during the succeeding half-dozen centuries; but history is entirely silent upon this subject during that period of time. In the ninth century, however, we again light upon it; the mother of Alfred the Great not only was a spinner of wool, or to use the name afterwards adopted, *a spinster*, but she taught her daughters the art. From this time forward, even to the commencement of the present century, most of the spinning of wool was done by women, and their industry was only equalled by their skill, it being the *pride of a good* spinster to make the finest yarn and plenty of it. Several remarkable examples of this skill are recorded, one even by the Royal Society: Mary Pringle, a Norfolk lady, earned this honour by spinning a pound of wool into fifty hanks, or 84,000 yards (nearly 48 miles), though this falls very far short of the accomplishments of a Lincolnshire lass, Miss Ives, of Spalding, who spun the same weight of wool into 168,000 yards, or 95½ miles of yarn, whilst the ordinary spinners of that time varied from (good) 13,440 yards to (superfine) 39,200 yards the pound.

The whole manufacture of wool, from its most primitive to its most perfect state, involves so much care, patience, and skill, that it must have exercised a potent influence upon the civilization of man. It was easy to pluck the flocks of wool from the living sheep, or from its skin after death, but before it could be spun into a yarn for weaving, it was necessary to comb out the entangled fibres, and clear them from the broken and stumpy hairs, and the finest short ones called technically *noils*, for which purpose bone combs were used (Fig. 7). They were ill-adapted for any

FIG. 7.

but the coarsest kinds of wools, such as those rude times produced, and they could not be employed without *great waste of* the material.

Until very recently combs with metallic teeth (Fig. 8) were used, and the more advanced wool-combers slightly improved upon them by making them with several

Fig. 8.

rows of teeth (Fig. 9), great care being taken in the latter form to have the teeth very smooth, round, and straight. It may seem to my readers, that with a comb like this in one hand and a tuft of wool in the other, there was no great mystery or art in combing; there is, however, no more delicate or curious material to deal with, as it is not desirable to have the fibres laid all in one direction, and, moreover, rough usage by so rude an instrument would produce much broken fibre. Hence it is the rule of the wool-comber to employ a pair of combs, and he has near him a small fire at which he can keep them both hot. He *first takes one* and fixes it in a notch in an upright post; he next takes a handful of wool previously sprinkled with oil to make it supple, and draws it through the teeth of the heated comb. Each pull

Fig. 9.

leaves some fibre in the comb, and in the end all but the noils are so placed. This process is repeated with the other heated comb until both are full. Both are then heated by the fire, and taken by the workman, one in each hand; that in his left he places with the points uppermost on his knee, while he reverses the other and draws its teeth through the lower one repeatedly, until the wool is all found to be laid in one direction, that is to say, with the fibres side by side. A close examination would show that the fibres from the combs are laid in opposite directions, but closely intermingled, as required by the special structure of the wool. We do not require a microscope to prove this to us, for it can be done by the sense of touch almost as well as by the eye; if we take from *the combed wool* a single fibre, and draw it carefully through the finger and thumb, we shall distinctly feel that it passes through, either smoothly or roughly, and *vice versâ.* A similar trial of a few fibres will soon prove that the combing has done its duty, and arranged the fibres pretty fairly in both directions, so that in the subsequent operations the projecting scales will come into play and perform their important part. This tedious process, requiring skill and perseverance, was but a few years ago the universal method, and so the operations in wools were almost limited to those of the longest staples, which are never the finest in quality. But this, as I shall show, when I speak of the introduction of machinery, has been entirely reversed, and the difficulty now is rather with the long than with the short-staple wool.

It must be borne in mind, that in the combing process by hand, however well conducted, the results were very imperfect, and were confined to a special class of wools, which led to great waste, as the noils were thrown aside as utterly worthless. These difficulties stimulated the minds of inventors, and it was at length found easy to treat short-staple wools like cotton, and by the use of properly constructed carding machines, to convert the shortest and finest into slivers, which could ultimately be converted into yarn, as perfect as ever the hand made, and infinitely finer.

Still the favourite wools were the long-staple kinds, and efforts without number were made to render them as easy of manufacture as the short ones, though the difficulties were great, and for a time insuperable. We are indebted to an Alsacian, M. Josué Heilmann, for first helping us to a solution of this difficulty. He constructed a combing machine, which could hold a tuft of wool by its middle and comb both ends; and when completed, he added this to another combed flock, and so built up a sliver of the desired length, and fitted for the succeeding operations of roving and spinning.

The properties of wool being of such a peculiar nature, the breeding of sheep was from very early times held to be of the utmost importance, and almost every variety raised has been found to differ in the quality of the wool. Climate and food are the two great causes of variation; consequently each country, and I may say with respect to British sheep almost every county, has or had its special breed. This tendency to variation has greatly decreased under the improved farming of the present century; which, by the more scientific treatment of the soil, according to well-defined general principles, has produced a more uniform system of feeding and tending sheep and other animals, whilst the extensive drainage and cultivation of the land has done much to equalize the climatic conditions of our country.

The following Table, which has been constructed with great care, and corrected by some of the most eminent wool merchants and others, will give the reader a correct idea of the numerous kinds of sheep and some of the variations in the quality of their fleeces. It will account for the fact that there are not less than eighty different kinds of wool to be found in the stocks of the dealers at the present time.

TABLE SHOWING THE VARIETIES AND BREEDS

WITH OTHER PARTICULARS RESPECTING

Varieties and Sub-varieties.	Breed.	Cross.	Staple.	Quality.
1. Spanish (Ovis Hispaniam of Linnæus).	Spanish	.. ..	..	..
	Class 1, Estantes or Stationary.	.. ..	Short	Fine
	a. Churrah ..	.. ..	Long (8 inches).	Rather coarse
	b. Merino.. ..	.. ..	Short	Very fine
	Class 2, Transhumantes or Migratory.			
	a. Leonese Negrettes ..	.. ..	Short	Fine
	Escurial or Estremadura.	.. ..	Short	Finest
	Guadeloup ..	.. ..	Short	Very fine
	Paulars ..	.. ..	Short	Good
	Infantados ..	.. ..	Short	Coarse and hairy.
	b. Sorian			
	Swedish	Merino and native	Long	Soft and fine
	French	Merino and Rousillon	Long	Soft and very fine.
	Danish	Leonese and native	Medium	Fine
	Saxony	Merino and best native.	Short	Finest
	Prussian	Merino and native	Short	Very fine
	Silesian	Merino and native	Short	Very fine
	Hungarian.. ..	Merino and native	Short	Fine
	Hanoverian ..	Merino and small native.	Short	Very fine
	New South Wales	Merino and South-down.	..	Fine
	"	Merino and Leicester	..	Fine
	Western Australia	Merino and Leicester		
	British (pure breed)			
		Merino and South-down.	..	Fine
	British	Merino and Leicester	..	Fine
	"	Merino and other native breeds.	..	Fine

OF SHEEP, FOREIGN AND BRITISH.

THE VALUE OF THEIR WOOL, ETC.

General Colour.	Average Weight of Fleece Washed.	Whether for Combing or Carding.	General Application, &c.
..	..	.. ..	Used in Leeds and Huddersfield.
Black and White.	4 to 5 lb.	Carding	Spanish wools obtained from the plains are of the Merino kind, and are chiefly used for woollen goods; but that obtained from the mountains is coarse and of unequal quality, and is used for low-class goods of various kinds.
White	..	Combing.	
White	Ram 8 lb., Ewe 5 lb.	Carding.	
Black, White, and Grey.	..	Carding.	
White	..	Carding.	
White	..	Carding.	
White	..	Carding.	
White			
White.			
White	9 lb.		
White	..	Combing and Carding.	
White	..	Combing and Carding.	
White	..	Combing and Carding.	
White	..	Combing and Carding	Silesian wool is almost if not altogether the finest in the world.
White	..	Carding.	
White	Ram 4 lb., Ewe 2½ lb.		
White	2½ lb.	Combing or Carding.	
White	3 lb.	Combing or Carding.	
White.			
White.			
White.			

TABLE SHOWING THE VARIETIES AND BREEDS

Varieties and Sub-varieties.	Breed.	Cross.	Staple.	Quality.
2. Common sheep (Ovis rusticus of Linnæus).				
Sub-variety (*a*), Hornless, or Lincolnshire.	Lincolnshire ..	Lincoln and Leicester	Long	Good and glossy.
Sub-variety (*b*), Muggs and Shetland.	Shetland	.. ..	Long	Very fine
Sub-variety (*c*), Ryeland.	Herefordshire ..	.. ..	Long	Medium
Sub-variety (*d*), Southdown.	Sussex	.. ..	Short	Fine
	Kent	Southdown and Romney Marsh.	Short	Medium
	Hampshire.. ..	Southdown and old black-faced Berkshire.	Short	Fine
	Berkshire	Southdown and old black-faced Berkshire.	Short	Fine
Sub-variety (*e*), Old Norfolk.	Norfolk	Southdown and Norfolk, or Downs.	Short	Fine
		Southdown and Leicester, or Norfolk half-breeds.	Medium	Medium
Sub-variety (*f*), Old Wiltshire.	Wiltshire	Southdown and Wiltshire.	Short	Fine
Sub-variety (*g*), Dorset.	Neighbourhood of Dorchester.	.. ..	Short	Medium
Sub-variety (*h*), Cornish.	Cornwall	Cornish and Leicester	Long	Coarse
Sub-variety (*i*), Old Lincoln.	Lincolnshire ..	.. ..	Long	Good
	Lincolnshire Wolds.	Lincoln and Leicester	Long	Good
Sub-variety (*j*), Romney Marsh.	Kent	.. ..	Long	Medium
	Southam Notts ..	Romney and Devon.		
Sub-variety (*k*), Bampton.	Devonshire .. Buckland.	Bampton and Leicester.	Long	Very fine
Sub-variety (*l*), Exmoor Nott.	Exmoor	Exmoor and Leicester	Long	Medium
Sub-variety (*m*), Cotswold.	Devonshire ..	Cotswold and New Leicester.	Long	Medium
Sub-variety (*n*), New Leicester.	Dishley	.. ..	Very long	Coarse
Sub-variety (*o*), Improved Teeswater.	Durham .. .. York	Teeswater and New Leicester.	Long	Fine
Sub-variety (*p*), Woodland *horned.*	Lancashire.. ..	Leicester and Woodland.	..	.. ..
		Southdown and Woodland.		

OF SHEEP, FOREIGN AND BRITISH—*continued.*

General Colour.	Average Weight of Fleece Washed.	Whether for Combing or Carding.	General Application, &c.
White	8 to 9 lb.	Combing	These are amongst the finest of the long-stapled or combing wools.
..	..	Combing.	
White	6 to 7 lb.	Combing.	
White and Grey.	3 to 4 lb.	Combing and Carding	Hoggets are valuable, and the long qualities are used in Bradford, the shorter ones in Rochdale, for flannels.
White	3 to 4 lb.	Combing and Carding.	
White	4 lb.	Combing and Carding.	
White	4½ lb.	Combing and Carding.	
White	3½ lb.	Combing and Carding	For flannels and low cloth.
White	6 lb.	Combing.	
White	3 lb.	Combing and Carding.	
White	3½ lb.	Combing and Carding	Livery cloth at Ilminster.
White	6 to 7 lb.	Combing and Carding.	
White	8 to 9 lb.	Combing.	
White	7 lb.	Combing.	
..	7 lb.	Combing.	
White	8 lb.	Combing.	
White	4 lb.	Combing and Carding.	
White	7 to 8 lb.	Combing.	
White	8 to 9 lb.	Combing.	
..	9 lb.	Combing.	
..	..	.. ..	This breed is nearly, if not quite, lost.

TABLE SHOWING THE VARIETIES AND BREEDS

Varieties and Sub-varieties.	Breed.	Cross.	Staple.	Quality.
Sub-variety (*q*), Silverdale.	Lancashire.. ..	.. ..	Long	Good
Sub-variety (*r*), Peniston.	West Riding (Yorkshire).	Peniston and Leicester.	Short	Moderate
		Peniston and Cheviot	Short	Moderate
Sub-variety (*s*), Isle of Man.	Manx Hills ..	.. ..	Short	Fine
	Manx Valleys ..	.. ..	Long	Fine
Sub-variety (*t*), The higher Welsh mountains.	The mountain sheep.	.. ..	Short	Fine
Sub-variety (*u*), Soft-wooled Welsh.	The Anglesea ..	.. ..	Medium	Not very fine
Sub-variety (*v*), Cannock Heath, or Sutton Coldfield.	Staffordshire ..	.. ..	Fair length	Medium
Sub-variety (*w*), Cheviot.	Northumberland	.. ..	Medium	Medium
Sub-variety (*x*), Dun-faced.	Northumberland Scotland			
Sub-variety (*y*), Black-faced.	Westmoreland .. Cumberland .. Northumberland Scotland	.. ..	Medium	Coarse
Sub-variety (*z*), Hebridean.	The Hebrides ..	.. ..	Long	Inferior
Sub-variety (*aa*), The Orkneys.	The Orkneys ..	.. ..	Long	Not very fine
Sub-variety (*bb*), Shetland.	Shetland	.. ..	..	The finest
	The flounder-tailed	Shetland and Dutch	Long	Medium
Sub-variety (*cc*), Wicklow mountains.	Cottagh	.. ..	Short	Medium
	The Irish	.. ..	Long	..
Sub-variety (*dd*), Herdwick.	Cumberland Hills	.. ..	Short	Very coarse
Sub-variety (*ee*), The Rass, or Roosh.	Bokhara.			
3. Barwall sheep (Ovis Barual, Hodgson).	Nepal.			
4. Hooniah sheep	Hooniah or black-faced sheep of Tibet.	.. ..	Long	Soft and fine

OF SHEEP, FOREIGN AND BRITISH—*continued.*

General Colour.	Average Weight of Fleece Washed.	Whether for Combing or Carding.	General Application, &c.
White	4½ lb.	Combing.	
White	..	Carding.	
White	..	Carding.	
White and Grey.	2½ lb.	Carding.	
..	7 lb.	Combing.	
White	2½ lb.	Carding	Chiefly used for flannels.
White	2½ to 5 lb.	Combing and Carding.	
White	6 to 7 lb.	Combing	Though generally much discoloured by smoke, it washes quite white.
White	..	Combing.	
White and Grey.	..	Combing and Carding.	
White	..	Combing and Carding.	
White.			
White	1½ lb.		
White	4 lb.		
White	2½ lb.	.. ..	Used for the flannels of Rathdrum, stuffs, bombazines, bombazetts.
..	3 lb.		The Irish breeds have been crossed with Leicesters, Southdowns, and Merinos in every country.
White	3 lb.	Carding	Used only for low-quality goods. This variety is remarkable for its hardiness and its peculiar sagacity in foreseeing and preparing for a coming snow-storm, which is done by the flock stationing itself on an exposed part of the hill in such a position as to cause the snow to drift, and thus leave an uncovered space for the sheep.
..	..	Combing	For ladies' dresses.

TABLE SHOWING THE VARIETIES AND BREEDS

Varieties and Sub-varieties.	Breed.	Cross.	Staple.	Quality.
5. Cago (Ovis Cagia, Hodgson).	Cago or tame sheep of Caubul.	.. ..	Long	Fine.
6. Seling (Ovis Selingia, Hodgson).	Nepal, central hilly region, and Eastern Tibet.	.. ..	Long	Fine
7. Curumbar ..	Mysore	.. ..	Short	Coarse
8. Gărăr	India	.. ..	Short	Coarse
9. Dukhun ..	The Deccan ..	.. ..	Short	Coarse.
10. West Indian	Jamaica	.. ..	Short	Fine and soft, but mixed with hair.
11. Brazilian ..	South American, Pernambuco.			
12. Smooth-haired (Ovis Ethiopia, Charlet).	African	.. ..	Not used.	
13. African (Ovis Guineensis Rail).	Senegal and Sahara.	.. ..	Not used.	
14. Guinea sheep (Ovis Ammon Guineensis, Schreber).	The Guinea breed.	.. ..	Not used.	
15. Morvant de la Chine.	China	.. ..	Short	Rather coarse, but peculiarly soft and silky to the touch.
16. Shaymbliar	India, Mysore ..	.. ..	Not used	..
17. Zeyla	Zeyla and Mokha	.. ..	..	..
18. Fezzan ..	Tripoli and Tunis	.. ..	Medium long	Inferior, fine
19. Marocco (Ovis Aries Numidæ, H. Smith).	Marocco	.. ..	Short	Inferior, fine and soft.
20. Congo sheep (Ovis Aries Congensis, H. Smith).	Congo	.. ..	Not used.	
21. Angola sheep (Ovis Aries Angolensis, H. Smith).	Angola	.. ..	Not used.	
22. Yenu, or Goitered sheep (Ovis Aries Steatiniora, *H. Smith*).	Angola	.. ..	Short	Fine and close

OF SHEEP, FOREIGN AND BRITISH—*continued.*

General Colour.	Average Weight of Fleece Washed.	Whether for Combing or Carding.	General Application, &c.
Some breeds black.	..	.. ..	For rugs and coverlets.
White, Yellow, Grey, Brown, Black.	..	Carding	East Indian wools are chiefly used for making blankets, but small quantities are used also for making carpets and rugs, and some of the longest for worsted manufacturers.
..	..	Carding.	
Yellow	..	Carding	Blankets, rugs, and carpets.
Reddish-brown. White.			
White and Grey.	..	Carding	For making the caps or fezzes.
White and Grey.	..	Carding	Used for felt goods, blankets, and rugs.
..	..	.. ..	Not used in Europe.

TABLE SHOWING THE VARIETIES AND BREEDS

Varieties and Sub-varieties.	Breed.	Cross.	Staple.	Quality.
23. Ixalus (Ixalus probaton, Ogilby).				
24. Cretan sheep (Ovis strepsiceros, Raii).	Crete	.. ..	Short, and much curled.	Soft and fine
25. Long-tailed (Ovis longicaudatus, Brisson).	Russia.			
	Odessa and Crimean.	Russian and Merino	Long	Very soft
	Wallachian ..	.. ..	Long	Silky, but inferior from admixture of hairs.
	Moldavian	.. ..	Long	Superior, but mixed with hair
	Greek	.. ..	Short curled.	Fine.
	Barbary	.. ..	Hair not used.	
	Donskoi	.. ..	Medium	Coarse
	Odessa..	Merino	Short	Very fine
26. Broad-tailed sheep (Ovis laticaudatus, Erxleben).				
Sub-variety (*a*), Fat-rumped sheep (Ovis stearopyga).	Tartarian, Indian, Syrian, Chinese, Russian, and South African.	.. ..	Long	Good.
Sub-variety (*b*), Persian.	Persian	.. ..	Long	Medium
Sub-variety (*c*), Fat-tailed.				
Sub-variety (*d*), Aora fiyel.	Abyssinian.			
Sub-variety (*e*), Bucharian.	Bucharian, Caucassian, Persian, and Astracan.	.. ..	Short	Fine, and much curled, especially in young lambs.
Sub-variety (*f*), Thibetan.	Tibetan	.. ..	Long	Soft and fine
Sub-variety (*g*), Cape.	Cape of Good Hope.	.. ..	Fur-like, and used as such.	..

OF SHEEP, FOREIGN AND BRITISH—*continued.*

General Colour.	Average Weight of Fleece Washed.	Whether for Combing or Carding.	General Application, &c.
..	..	Carding.	
White.			
White.			
White.			
White and Grey.	..	Combing and Carding.	
White	..	Carding.	
White, Black, Fawn, Yellow, Brown, Grey.	..	Combing	Used for nusmuds; the unyeaned lambs' skins for pelisses.
Black; Grey in unborn lambs.	..	.. ..	Much prized in the unyeaned state, when the delicate grey curled skins are taken and dressed for furs, and the black for making the spots of miniver and for wearing as fur.
..	..	.. ..	Used for dresses.
..	..	.. ..	As fur for trimming dress, bags,&c.

TABLE SHOWING THE VARIETIES AND BREEDS

Varieties and Sub-varieties.	Breed.	Cross.		Staple.	Quality.
Sub-variety (*h*), Ovis Aries appendiculata.					
Sub-variety (*i*), Belkah.	Palestine and Plains of Belkah.	..	..	Short	Thick
27. Many-horned sheep (Ovis polyceratus, Linnæus).	India and Nepal The Dumba.				
28. The Pucha..	Hindostan Dumba				
29. Short-tailed .	Northern Russia	..	..	..	..
30. Sheep of Tartary.	Tartary	..	..	..	..
31. The Madagascar.	Madagascar ..	..	..	Short	Fine
32. The Bearded	West African ..	..	..	Hair not used.	..
Javanese	Java	..	..	Short, and finely curled.	..

The character of the two leading kinds of wool having been fully explained, I have now to show how they are worked up into various fabrics, bearing in mind that the peculiar differences in their structure mainly depend upon the excess or deficiency in the felting qualities of the wool used, or in other words, whether they are long or short-stapled varieties. The results, in the case of long-staple wools, are cloths called *worsted* goods, while those made of short-stapled wools are *woollen* goods. The latter, or a mixture of the two, are also made into *felts*, but for this purpose the *noils*, or broken and short fibres separated from both varieties in the processes of combing and carding, are generally used. These distinctions exist, not only in

OF SHEEP, FOREIGN AND BRITISH—*continued.*

General Colour.	Average Weight of Fleece Washed.	Whether for Combing or Carding.		General Application, &c.
White.				
..	..	..	..	None of these are found in our markets.
..	..	..	..	
..	..	..	..	
..	..	..	..	
White	..	..	..	

the wools of different sheep, but commonly also in the wool produced by a single animal, and the various manufactures depend essentially upon their being carefully separated from each other. The first operator who is called into requisition is the *Wool-stapler*, whose business is, with the nice tact only acquired by great experience, to open out the fleeces, which, if they have been carefully sheared, still hang together as if attached to the skin. Having spread an open fleece before him, he picks it to pieces, lock by lock, and throws each lock according to its quality (which is to a great extent dependent upon the position that it occupied on the animal) into a basket or a separate heap on his bench. Usually a fleece furnishes eight or ten qualities, the names for which vary somewhat in different localities; but as the Yorkshire terms have been well known for a great length of time, I prefer to give them, as they are generally understood in the trade.

The first and finest quality is called *picklocks*; second, *prime*; third, *choice*; fourth, *super*. These are wools of the best kinds; while the remainder are inferior, and have the following designations, viz.: fifth, *head-wool*, or the chief of the inferior division; sixth, the *down-rights*; seventh, *seconds*, which is that grown on the throat and breast; eighth, an inferior kind to the last, called *abb*; ninth, *livery*, the long coarse wool about the belly; and tenth, *short coarse*, from the breast of the animal.

Formerly wool stapling was a special trade carried on by persons who bought the fleeces, or wool in bales, and sorted them, to be sold as required. To a certain extent this practice still continues, but many large manufacturers now employ their own staplers, and stapling forms the first in the series of processes which I am about to record as taking place in the large establishments, which receive wool and send out manufactured goods ready for the market.

Before the selected wools can be of any use to the spinner, they require to be washed free from the natural secretion, or *yelk*, which gives them a greasy feel, and also from the dirt which is rather abundantly distributed through the fibres. In some countries, especially in our own and in our sheep-rearing colonies, the first and most important washing precedes the shearing, and is either effected in the old-fashioned way of driving the animals one by one into a pool of running water and cleansing them by manual labour; or else some of the many improved kinds of sheep-washing appliances, such as those made by Gwynne and Co., of London, are now much in use on large sheep farms. By the latter a large number of sheep can be washed in a short time without the trouble of the old method, in which a struggling animal had to be held whilst undergoing the operation. The general principle of these new methods is this: the sheep are made to go into one or more pens, from which they cannot escape, and whilst so imprisoned water from numerous jets is driven with great velocity upon and through the fleece, so that the dirt is speedily removed. In Gwynne and Co.'s apparatus hot and cold water are both used, and the bars of the pen are themselves tubes perforated with small holes, through which the water rushes with the force of a spray bath. Before they get into the cages, the animals are driven into a large bath, in which they swim about till they find the only outlet in a long narrow passage, at the end of which they ascend into an open space, where the attendants are placed to give them admission into the cages and regulate the time of their remaining there.

Sheep-shearing follows the washing immediately after the animal has got its coat well dried. This operation for many centuries knew no change, the hand clippers or shears having been continuously in use as the only means of severing the fleece. Now, however, the immense demand for the material has stimulated man's ingenuity, and mechanical cutters are used, which do the work much more rapidly and effectively.

But however well the wool may have been washed on the animal's back, it is not enough for the spinner's purpose, and moreover very large quantities have never been so cleaned at all; therefore the process of *scouring* becomes necessary. Formerly this consisted simply in soaking the wool for a time in a warm alkaline solution, squeezing it as dry as possible, afterwards rinsing it in clean soft water, squeezing it again, and then drying it. Now, however, the mechanical *Scourer* does the work in a most efficient manner, and with comparative rapidity. The apparatus consists of a long, narrow trough, partly filled with the warm alkaline water necessary for removing the grease, &c. The wool is regularly fed into the trough at one end, and as soon as it enters the water it is dragged forward through it by four arms in succession, so that by the time the locks reach the other end of the trough they are both washed and laid straight, to be received on a most ingeniously contrived *lifter*, which takes them out of the liquid, and passes them in regular quantity to two rollers, between which they are drawn and squeezed nearly dry. After this the wool is usually washed in an abundance of clean cold water, to get rid of the soap still adhering to it. It next passes into the drying machine, where it is exposed to a blast of air, either warm or cold, as required, until every particle of moisture is driven out. It is then transferred to the *willowing*, or *dusting* machine, in which teeth, fixed on revolving cylinders, disentangle the locks, whilst a blast of air from a mechanical fan blows out the dust and drives the wool through in a beautifully flocculent state, well fitted for the next series of operations.

At this stage, some kinds of wool present a serious difficulty, arising from the entanglement of those troublesome seeds of plants called *burrs*, which become attached to the sheep whilst grazing. Formerly very *burry* wool could not be used, but the invention of Platt's Burring Machine removed the difficulty, and successive improvements in it have made the presence of these intruders of very little consequence. The worst wools in respect of burrs is that from Buenos Ayres, but a Belgian burring machine by M. Martin, of Vervier, is said to completely free 300 lb. of wool per hour even of that quality.

Let us now look back and see what has been done since the wool was shorn from the animal. The *Stapler* has sorted it into various qualities, which have passed into the hands of the manufacturer requiring them for his particular manufacture. Before using this, however, he has washed it, dried it, opened and dusted it in the *Willow*, after which the burrs have been removed, and it is now in a fit state for carding or combing, except in one respect. These operations have freed the wool from its natural lubricant the *yelk*, or secretion with which nature furnishes the animal to keep the scaly surfaces from interlocking and forming a coat of felt on the body; but the wool has consequently become somewhat brittle and over-dry, and it has to be oiled with some thin, clear vegetable oil, such as olive, rape, cotton seed, &c. The more lightly and equally the oil is distributed through the wool the better, not only because it would not work so well if irregularly diffused, but, as oil is always a dear article, it would increase the expense. For this purpose many ingenious inventions have been introduced, but none so successfully as the *oiling machine* of Mr. George Leach, of Leeds, which is applied to the willowing machine, and as the wool passes, distributes through it a minute shower of oil, in a spray so fine as to be almost invisible.

The wool being oiled, if of the short kinds, is now weighed, in order that it may be supplied in regular quantities to the first carding machine, or "scribbler," upon the feed-board of which it is spread evenly, and is carried on by the feeder to the cylinders. These are covered with "cards," or tightly-fitting belts of leather, indiarubber, or other suitable material, thickly set with steel points, slightly bent, and so arranged that they nearly touch. They are also bent differently on the rollers which revolve in opposite directions, so that any knotted portion of the wool is pulled, as if between two combs moving away from each other, and the fibres are thus disentangled and laid straight. The carding engine is a simple machine in principle, but a very complicated one in its construction, for it has not only to ensure that not even the minutest knot or entanglement shall escape its operation, but, when all the fibres are laid straight between its innumerable teeth, they have, by means of another mechanical contrivance, technically called a "doffer," to be removed in a continuous film of fibres, or a series of films. Each of these pass between endless bands of leather, running on small rollers, which press or "condense" them by a slightly lateral as well as forward motion, and form the first stage in making wool into yarn. There are many intermediate parts, and even several machines, which all do useful and necessary work to realize this result; but without the aid of a series of diagrams, not easily made intelligible to the general reader, it is impossible to give more than an outline of the operation, and thereby explain its simple principles.

For many years past, immense efforts have been made to bring the machinery used in the manufacture of wool to all possible perfection, and in this respect England and Belgium have been pre-eminent, and these large machines are now turned out with a nicety and precision scarcely surpassed by the watchmaker.

As my remarks so far apply only to the machinery for "*carding*" wool for the use of the manufacturers of "woollen" cloths, I will, to avoid confusion, explain the subsequent processes until the completion of the fabric, and afterwards describe the method of preparing the long kinds of wool by "*combing*" for the manufacturer of "worsted" goods.

The wool, passing off carded from the carding machine as before described in a continuous film, is gathered into a small compass by being made to go through a ring or smooth groove, in which condition it is called a "*sliver*," which, by the motion of the small rollers of the condenser before mentioned, is

D 2

rubbed into a cylindrical, but as yet untwisted cord. The most improved machines give off as many as seventy-four of these rounded slivers, which, as they leave the condenser, are collected into three sets of twenty-four each, the two outside ones being rejected as imperfect, and used over again. Each set is wound upon a revolving spool or large reel. Some idea may be formed of the work done by one of these machines, when it is known that 56,000 yards of sliver pass through the condenser in an hour, and so fine are the individual slivers that 1 ounce is the weight of 352 yards. These condensed "slivers," or "slubbings" as they are now called, are removed when the spools are full and transferred to the spinning machine or mule, one of the most beautiful mechanical contrivances ever made. It consists of a fixed and a movable part. On the former the spools filled with the *slubbings* are placed on spindles, and the end of the slubbing is passed between wooden rollers, which can be so adjusted as to regulate the fineness to which the yarn is to be drawn. It then passes on to the spinning spindles. When thus arranged, the movable frame bearing these spindles runs out to some distance, carrying with it all the threads, which are drawn through the rollers and twisted. It then returns, and the length of completed yarn is wound on bobbins. Every spool and spindle of a self-acting mule may be said to represent one of the old-fashioned spinning wheels, except that the produce is ten times greater; and as mules with two hundred spindles are common, the work of one of these machines equals that of two thousand hand-spinners.

From the commencement of the scribbling up to the beginning of the spinning process, several minor but important operations have been purposely omitted in this description to avoid confusing the reader by their similarity one to another, but their object is by successive cardings to prevent too great parallelism in the fibres of the wool. The object of the wool carder is to produce slivers in which the fibres cross each other as much as possible, so that when they are twisted into yarn, innumerable ends project, and the thread has a hairy appearance, a condition very opposite to that aimed at by those who work in the long wools for *worsted* manufacturers. Many varieties of yarn are produced for making the various kinds of woollen fabrics, but they are all divisible into two classes, the *warp* yarns and the *weft* yarns, the former for arranging lengthwise in the loom, and the latter to be thrown through the warp-threads by means of the shuttle. The-warp threads have to be specially prepared for the loom, being first transferred from the mule-cops on to bobbins called *warpers-bobbins.* This is necessary to enable them to be wound off by the warping machine, a huge reel of several feet diameter, which takes off the contents of many bobbins and forms them into skeins with the thread very regularly arranged for placing on the loom. Before that, however, the thread is sized in order to prevent it from chafing, and to give it sufficient strength to bear the strain upon it in the process of weaving; for all the yarns used in weaving woollen cloths are tender, being only slightly twisted, in order to leave its felting properties as free as possible. Weaving is the same with all textile materials, and with few exceptions is now done by power-looms. When woollen cloth comes from the loom, it has a very coarse appearance, and, if held up before the light, is seen to be full of small openings at the intersection of the threads, and the surface has a "fuzzy" appearance, being in this state technically called "*roughers*." But subsequent operations entirely change this character. It is necessary in weaving woollen cloth, in order to ensure fineness of quality, that every *shoot* or weft-thread should be beaten up with great regularity of force, so as to ensure the same number per inch all through the web; otherwise it is apt, when finished, to have a puckered and wrinkled appearance instead of the smooth and glossy surface so much desired. The web of cloth, after the weaving is completed, is stretched on a frame, and is carefully gone over by women, who pick out every small nib or other imperfection. It is taken to the washing machine, where in a mixture of urine, blood, and salt, or soda and water, it is completely cleansed from oil and size. Much care is required in this operation to ensure its being thoroughly done, which is shown by its having acquired an elastic softness to the touch.

If not wool-dyed, that is dyed before the carding takes place, which is the case with all the best cloths, it is dyed after leaving the washing machine, and next goes to the *fulling mill*, where it is milled or beaten with the fulling stocks, kept carefully supplied during the process with thick warm soapsuds, which are said to nourish the fibre of the cloth. The result of this process, and of another now generally used instead of it, in which the cloth is passed through a milling machine, where the web, saturated with soap and water, is submitted to great pressure, is to work the fibres of the wool into such close contact that the scales interlock closely, and, instead of the comparatively loose texture noticed before, the web is closely felted, and so compact as to be free from all appearance of having been woven. It now goes back to the washing machine, where it is thoroughly washed to free it from soap and other impurities, after which it is *tented* and dried. Tenting consists in arranging the web of cloth on very long frames, with small tenterhooks on each side at short intervals, the edge or selvage being hooked on to them, and here it is left to dry naturally or in some cases more quickly by heated air. When dry, it has a blankety look very unlike that of finished cloth. The next process is extremely curious, and one in which we are obliged to have recourse to nature, in raising the *nap* or *pile* on woollen cloth. From the earliest times when it was first practised down to the present, we have been obliged to use a vegetable product, the *teazle*, or the ripe fruit of the plant known to botanists as *Dipsacus fullorum.* It is a composite plant with a high conical receptacle, from which spring numerous paleæ, each ending outwards in a spine having a hooked point—the points all being recurved in the same direction. The cones of spines are often about two inches long, are cut in halves and arranged in frames, so that a large and even surface of the spines is obtained, and over this the cloth is passed in such a manner, that the hooks of the spines catch the surface and tease out much of the woolly fibre, giving it a soft velvety appearance. It then passes through a machine called the dressing machine, which pares down the irregular pile raised by the teazle frames to a perfect uniformity of surface, and so close that it is a marvel how the fabric itself receives no injury. No mechanical contrivance, and there have been very many, has superseded the teazle; it would be quite possible to form metallic hooked points quite as delicate and certainly more regular, but the horny elasticity of the teazle has never been imitated. The secret of its great importance is that it gives when necessary and does not tear the threads, but only pulls out those points which are not strong enough to resist. That is all which is wanted, and to do more is to seriously injure the texture of the fabric. When it is desired to produce a fine quality of cloth, it now undergoes the process called *lustering* or *decatting*, which consists in winding the web tightly but very smoothly on an iron roller. Great care must be taken in this operation, for if any wrinkles are made, they will leave very disfiguring marks. When perfectly rolled, the cloth is put into water heated from 160° to 180° Fahrenheit, and kept immersed in it for six or eight hours, after which it is taken out and allowed to dry on the rollers. This operation is repeated eight to ten times and occupies altogether about a fortnight. These, generally, are the processes by which wool is converted into woollen cloth, though they are varied by different manufacturers and for different qualities of cloth, some of which want less careful manipulation, whilst others again require additional processes, such as double milling, hot-pressing, &c.

In treating the long wools by combing, an entirely different arrangement is necessary from the very beginning, at least as soon as the wool is washed, willowed, and dusted. Even in the last-mentioned process the difference of preparation begins, for care is taken not to make the wool too dry, as that would give it a tendency to curl, which, though very desirable with the short wool, is not so with the long. In this state it is taken to the "preparing machine," into which it is fed in the same way as in the carding machines. It passes through a series of three "gill-boxes," the "gills" consisting of rows of steel teeth set with great regularity. The teeth are strong, and about 1½ inch high in the first set, but they are finer and closer in each succeeding "box," so that the wool is disentangled and roughly parallelized, and thus prepared for the more perfect combing which it has to undergo. It issues from the "preparing machine" in a continuous sliver, which falls into and is coiled in tall tin cylinders, or "sliver cans," about 4 feet deep and 10 inches in diameter. When filled, twelve of these slivers are taken to a fourth or finishing "gill-box," and being placed in a row, the ends of the twelve slivers are passed into the machine and then through the gills of the finishing box, forming one united sliver. Then twenty of these "finished slivers" are similarly placed at the combing machine, the technical name of which is "Lister's Nipping Machine." This really wonderful contrivance, the invention of Mr. S. C. Lister, of Bradford, in Yorkshire, is one of the most remarkable inventions of modern times. It does the work of at least fifty men or hand-combers, and, what is still more remarkable, does it much better. It has consequently entirely superseded hand-work, and has given a development to the trade of the neighbourhood in which it was invented, which has placed it in the foremost rank for worsted manufactures, and has added to the general wealth of the country to an enormous extent. The "Lister Nipping Machine" is a circular revolving frame, into which the ends of the slivers are drawn, and, by a series of operations, which can only be really understood by watching the machine itself when in motion, are pulled into tufts which are perfectly combed, while the noils are also separated in such a manner, that they are rendered available for the carding machines in the best possible condition. The "Lister" is an automatic machine of such wonderful construction, that it would seem to those who have watched its operations impossible to improve upon it, nor has this yet been done in the case of long-wool combing. The requirements of the worsted trade, however, which produces such an endless variety of fabrics, demanded a machine which would also comb short wools, and this has been furnished by Mr. Noble, whose machine, working side by side with that of Mr. Lister, was seen by many thousands in the Annual International Exhibition of 1871, when both excited great surprise by their wonderfully perfect operations.

From both of these machines a continuous sliver is delivered, which either passes through other "gill-boxes" for more complete "finishing," or goes at once to the "drawing frame," to be drawn out to greater tenuity; and afterwards to the spinning frame, to be spun into yarn ready for the weaver.

I have now briefly, and it is hoped intelligibly, sketched the methods by which the qualities of wool are dealt with in order to produce the two leading distinctions in the cloth trade. The varieties of fabric are almost innumerable, and are perpetually varying according to the changes in fashion, though there are a certain number of fixed kinds which are mentioned below for the information of those curious in such matters.

Thus of woollen cloths we have:

Doeskins, which hitherto have been hand-woven, and are stout and firm, milled in the new milling machine, and well dressed on the face. In the arrangement of the loom, seven threads of the warp come up to the face, whilst twelve threads of the weft fall to the back, forming what is technically called a seven-harness-cloth.

Cassimeres and *Kerseymeres* differ from the last only in being four-harness, that is, four instead of seven threads in warp and weft; and in the case of the kerseymeres, the web being subjected to an extra "milling," which renders it more compact.

Sataras—ribbed cloths—highly dressed, lustred, and hot-pressed.

Venetians.—Woven as twills.

Meltons.—Stout cloths not dressed or finished except by paring, an operation which is not done equally on both sides, the upper or under, as the case may be, being more or less finely pared down.

Beavers.—Also stout cloths with only the face pared; these are also milled, until they are hard and very compact.

Deer-skins.—This cloth is somewhat like Venetian, but has thinner ribs and altogether a thinner texture, owing to the use of a yarn for warp and weft of equal or nearly equal thickness.

Diagonals, or Fancy cloths, with, as the name implies, a sort of lozenge pattern woven in it, or stripes crossing each other at very acute angles, varying much according to the fineness of the lines and the size of the lozenge formed by them.

Bedford Cords.—Usually drab-coloured ribbed cloths of great strength and durability.

Tweeds are cloths woven of short or medium wools, but very lightly felted, and are mostly of Scotch manufacture.

Of worsted cloths, the following are well-known varieties:

Says are amongst the oldest of our worsted fabrics, which was alluded to by Shakespeare in 'Henry VI., Part II.,' "Well, he shall be beheaded for it ten times. Ah, thou *say*, thou serge, nay, thou buckram lord!" It is still manufactured, and in black wool or wool dyed black, and is used for clerical and academical vestments.

Serge, also alluded to in the above quotation, is still extensively manufactured, although it originally meant a kind of blanket, from the Spanish term Xerga, a woollen blanket.

Satteens, plain, figured, and mixed or *melanges*, are thin lightly-woven cloths for ladies' dresses.

Reps are heavier, and from the method of weaving have a transverse ribbed appearance.

Cords resemble reps, but the ribs are longitudinal.

Moreens, formerly *Moireens*, are watered cloths.

Merinos, finely woven cloths, originally made from the fine Spanish wool called *Merino*, from its having been raised under the inspection of the *Maiorina*, or major superintendent.

Paramattas. — Fine cloths originally made from Paramatta wool with silk warps, though now woollen, are more generally used.

Camlets are fine thin plain-woven cloths, formerly much worn in this country. They are of great antiquity, and derive their name from having been made of camel's hair, the European camlets being imitations of oriental fabrics; as also the—

Damasks, called after Damascus, whence they originally came. In all probability, however, they were silk fabrics, which in our less luxurious country were imitated in wool.

Shalloon, from Chalons, the place of its original production, also ranks amongst the most ancient manufactures of wool, and is thus alluded to by Chaucer:

> "—— a bedde
> With shetes and with chaloun̄es faire y-spredde."

Shalloons were thin cloths made with hard-spun yarns.

Although these varieties of worsted cloths are usually of wool only, they are often made with cheaper materials for the warp, such as cotton. The following, on the contrary, are most generally made with cotton warps:

Crapes, made in imitation of the silk fabrics of the same name, are passed through rollers, which give the crimped appearance to the surface of the webs.

Coburgs, or Cobourgs, as they are sometimes called, are thin twill-woven cloths.

Tammies, originally made all of worsted, or *estame* in French, whence they derived the name, are now made of wool with cotton warp. They are highly glazed and dyed in bright colours, and they are still favourite fabrics, although amongst the oldest made in this country.

Delaines are light fabrics for ladies' summer dresses, originally called muslin de laine, or muslins of wool.

Lasting, a firmly woven cloth of hard-twisted yarn, used for ladies' boots chiefly.

Orleans Cloths are plain-woven cloths, in which thin cotton warp and worsted weft are brought to the surface in regular alternate order.

These are a few of what we may call the leading types in woollen and worsted fabrics, but their varieties are innumerable and beyond the power of description, for they depend upon the fancy of the manufacturers, and often are so nearly alike that the name is the only difference. No true classification of the kinds of our textile manufactures has ever been attempted, although it would, if correctly done, be a most valuable record;

and therefore all attempts to give detailed descriptions of the products of our looms are attended with difficulty and a want of satisfaction to both writers and readers. It is remarkable that a country like ours, more dependent than any other on its manufactures, has never yet attempted a systematic history of them, whilst every Continental state having a polytechnic school has made praiseworthy efforts in this direction, and has stimulated its learned men to produce valuable treatises upon these subjects.

My remarks have so far been confined to the manufacture of sheep's wool, but since the year 1836 another material has attained an immense importance in our worsted trade, or rather, I may say, two materials, for they have gone hand in hand, viz. *alpaca* and *mohair*. The introduction of the first, and the immense benefits that it has conferred on the manufacturing interests of this country, are entirely due to the sagacity and perseverance of Sir Titus Salt, whose vast additions to our wealth and industry have been only slightly acknowledged by the title bestowed upon him by the Government, but largely by the high appreciation in which he is held by his grateful countrymen. Before he undertook the difficult task of combing such an apparently intractable wool as that of the alpaca, others had tried and failed, but he conquered every obstacle; and if no other result had been obtained than the erection of the princely manufactory of Saltaire, with its busy workers and its vast machinery, it would have been an immense triumph, for it has given an impulse far and wide. Aided by Mr. Lister's wonderful ingenuity, works have sprung up in all directions around the parent one, in which the long fibres of the wool of the llama,* and its allies the Alpaca, Guanaco and Vicugnia, together with the wool of the Angora goat, are worked with as much ease as that of the sheep, producing delicate fabrics which are in demand all over the civilized world. Although the four species of Auchenia are mentioned, if indeed they are true species (which many naturalists doubt), only the wool of the alpaca is used to any great extent in our manufactures, the others being only occasionally employed. The fabrics made from them and from the Angora goat † are amongst the materials of our looms which almost rival the products of silk, and are especially adapted by their lightness for wearing in hot climates, giving rise consequently to a great foreign trade.

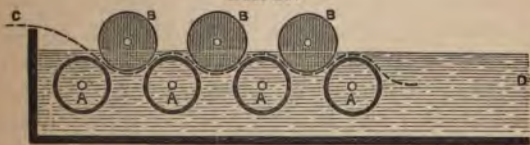
But there is another application of wool to which only a slight reference has been made, namely, the manufacture of felted cloth, which has lately been brought to such perfection, that for many purposes it is a rival to the woven fabrics. This is principally carried on at Leeds, where the works of the Patent Cloth Company turn out large quantities of fine felted cloths for table-covers, druggets, upholstery, cloths, and even for ladies' woollen jupons. The process of manufacture is interesting. First, the properly washed and cleaned wool is passed through an immense carding

* Auchenia lama; Auchenia Paca; Auchenia Guanaco; Auchenia Vicugnia.

† Capra hircus.

machine, which delivers it in a sliver several feet broad, but not much thicker than a cobweb, and this is received and wound on a roller, until a sufficient length has been obtained. Then a number of these rollers are placed in another machine, in which they are made to unwind the slivers and deposit them one over another, until a lap of the required thickness is formed, this being often an inch, necessitating a great number of slivers. This lap is then made to pass through a series of wooden and tin rollers arranged thus—

Fig. 10.



The upper ones are of solid wood, the lower of tin, hollow and filled with steam, and all placed in a long, shallow, but broad trough of hot water. The lower rollers simply revolve on their axes, but the wooden ones, besides this motion, have a slight movement from side to side, which causes them to rub the lap of slivers, and induces the fibres of wool to combine and felt together as they are carried along by the revolutions of the two sets of rollers, the heated water greatly helping in the operation. In the end, what went in as a thick sheet of wool, like wadding, comes out a compact thin cloth, in some instances as fine in appearance as a kerseymere, which, after being dyed or printed, is tentered and pressed, and is then ready for sale. This process admits of very inferior wools and the noils of wool, and even of flax, being mixed and made into low-class cloths for druggets and other coarse materials.

There is another phase in the manufacture of wool which must not be omitted, as within a very few years it has attained to immense importance in England. I have shown the microscopic structure of wool, and if it is borne in mind that no amount of wear can entirely remove either its scaly or curly structure, it will then be seen that if we unweave mere fragments of cloth, and reduce them again to the condition of wool, we can respin, reweave, redye it, and bring it out again as a new material. If the rags so treated are those of woollen cloth, they are called *mungo*, and if of worsted cloth, *shoddy;* and to show the importance of these materials, formerly considered valueless in the trade of the country, we imported from abroad, besides carefully collecting and utilizing our own rags, not less than 24,827 tons in 1872. Thirty years ago the rag-pickers who collected linen rags for the papermaker, carefully rejected every particle of woollen or worsted cloth, but now they place quite as much value upon them. There is a popular prejudice against the employment of these materials; but so well are they used, and such fine goods are made from them, that not one in a hundred thousand of those who wear them have the slightest suspicion of their origin. Instead of a disgrace to our manufacturing industry, the employment of mungo and shoddy is a credit to the age, for waste is a sin against the present and future generations.

Even after the conversion of these rags into a really excellent material, there is a certain amount of broken fibre which cannot be woven; nevertheless it has its uses, and is dried and pulverized, or brought into such a condition that it can be used by the manufacturer or printer of wall papers in the form of *flock*, so that practically nothing is lost of this valuable product.

The extent to which the trade in wool and its manufacture has increased in Great Britain can only be fairly estimated by a reference to the past. Thus, in the first quarter of the twelfth century England not only raised enough wool to supply her own wants, but exported what were then considered large quantities to other countries, and chiefly to Flanders. Now, in all probability, although sheep have increased a hundredfold, we are so far from being able to supply the wants of our manufacturers, that we imported in the year 1873, 313,496,742 pounds, of the value of 18,983,876*l.*

Such are the mutations of trade, and such are the wonderful results of industry, unfettered by laws made without a full knowledge of the true principles of political economy. In 1128 fines were levied on the export of wool, and smuggling out wool was a thriving business; whilst now it comes freely in or goes freely out, according to the fluctuations of trade, and produces more millions of wealth to the country than it then did hundreds of pounds sterling.

FLAX.

By W. T. Charley, D.C.L. (Oxon.), M.P.

The name, "flax," is applied indiscriminately by Dr. Johnson to the flax plant, and to the valuable fibre which it yields prepared for spinning. The flax plant belongs to the natural order *Linaceæ*, and in virtue of its commercial uses is styled by botanists, *Linum usitatissimum*, and its seeds produce linseed oil and linseed cake. The stem of the plant consists internally of the woody shore or boon; externally, of the fibre from which linen is made. Chemically analyzed, the flax plant is composed as follows: Organic matters, 41·97 per cent.; water, 56·64 per cent.; ash, 1·39 per cent. The farmer, who wishes to make a profit by the cultivation of flax should be careful to select the plump, heavy, and shining seed of the best and purest brand that can be procured. The seed best adapted for Irish soils is Riga. By selecting low-priced job lots, the farmer may effect, indeed, an immediate saving, but is certain to incur the risk of ultimate loss, if not ruin; for the most skilful husbandry cannot produce a good crop of flax from impure seed. The finest seed having been obtained, and sifted from all impurities through a wire sieve, equal care must be taken in the choice of a suitable soil; the best is a nice dry loam, not too light nor yet of a clayey nature, as nearly as possible of uniform quality, both as to tilth and the chemical compounds which it contains. In noted flax soils, both at home and abroad, silica has been found to predominate, in proportions varying from 60·94 to 83·93 per cent. Lime, alumina, and iron have also been invariably present, though in very small quantities. In Ireland, where the cultivation of flax is carried on upon a much larger scale than anywhere else in the United Kingdom, the following rotation of crops has been proved by experience to be the best: First year, grass; second, oats; third, potatoes and turnips; fourth, wheat; fifth, flax, clover, and beans. On poor lands flax is often sown with advantage after potatoes. If this rotation be observed, and the same soil be not cropped with flax oftener than once in from six to ten years, it will be found by the farmer not to be an exhausting crop, but quite the reverse, for it will be in reality an extra crop grown without manure. If grown oftener than once in six years, manure should be used, whilst thorough drainage and early ploughing of the wheat stubble are essential to success. The latter should be ploughed once or twice in February or early in March, if the soil is light, in autumn and again twice in spring, if it is stiff or heavy. In April it should be well harrowed, to free it from lumps, and picked clean of weeds. Deep tillage is recommended, to enable the roots of the plant to penetrate in search of nourishment, and acquire sufficient vigour to sustain so tall a stem. The surface of the ground should be made as even as possible, to ensure uniformity in the length of the stems. After harrowing the soil and freeing it from weeds, the seed should be sown up and down (not across) the ridge (or rig) at the rate of a Riga barrel, or three-and-a-half barrels per Irish acre, equal to two (or two-and-a-half) bushels per statute acre. The quantity must, however, to some extent depend upon the kind of crop that the farmer desires to obtain. If he wishes for a large yield of superior fibre, he should sow rather a full quantity; if a large yield of bolls or seed capsules, he should sow rather sparingly. The seed when sown should lie in a thoroughly dry, deep, and clean bed, about one inch below the surface, and should be covered in by passing over the ridge (or rig) a fine seed-harrow, once up and down and once crosswise, and a light roller. When the plant has reached the height of five or six inches from the surface of the soil, it must be carefully freed from weeds, the weeders working with their faces *towards* the wind, so that, as they pass on, the plant may have its assistance in regaining its upright position. The knees of the weeders should rest (as in Belgium) upon a cloth or straw mat, and they should always press the stems in one direction, as if these get twisted, the crop will be spoiled.

When the flax attains its full growth and approaches maturity, its tall and elegant stems of soft green hue are surmounted by a *corona* of delicate branches, each branch supporting a bright blue flower. A field of flax in full bloom, agitated by the passing breeze on a sunny day, is a very pleasing object. Not even the "free and happy barley," with its lustrous golden tints, can add equal beauty to the landscape. In a few weeks the bright flowers fade and fall off, to be succeeded by rough globules, or capsules, full of seed. The flax-seed which is saved at home should generally be used for feeding cattle, or be sold to the oil mills, the Riga flax seed being, as already stated, preferable for purposes of reproduction.

As in this article the flax plant is considered solely in its relation to the manufacture of linen, of which its fibre forms the raw material, the attention of the reader will be invited to those processes of treatment which have for their object not so much the preservation of the seed as the production of a superior fibre. The farmer who aims at the production of a superior fibre must pull the plant before it has attained its full maturity, i. e. after the stalk, to the extent of two-thirds of its height, has become yellow, and while the bolls or seed capsules are changing their hue from green to a pale brown. A fine day should be selected for the process of pulling, which requires to be very carefully performed. Where the stems of the flax are of different lengths each should be pulled separately and kept separate, as should also stems prostrated by the wind or saturated with rain. If there is much second growth, the longer stems should be grasped by the puller just under the bolls, leaving the short stalks behind, and the lower ends should be kept in all cases perfectly even. The handfuls of pulled flax will be laid across each other, so as to remain distinct.

The next process is the rippling, which ought to be carried on in the same field; the object being to separate the bolls, or seed capsules, from the stems.

Flax should be rippled as soon as pulled. The ripple is a kind of large comb composed of iron teeth set in a wooden frame, which is screwed down to the centre of a 9-feet plank resting on two stools. The ripplers may either stand, or sit astride, at opposite ends; and a winnowing sheet is placed underneath on the ground to receive the bolls as they are rippled off. The rippler seizes a bundle of freshly pulled flax about six inches from the root with one hand, and with the other he spreads out the tops like a fan. He first draws one half through the ripple, and then the other, though sometimes the entire handful is drawn through at once. He then lays the bundle, from which by this process the bolls have been separated, down at his left side, crosswise, to be tied up in sheaves and removed. Each pair of ripplers should be seated, or stand at such a distance on either side of the comb, as to be able to strike it alternately. Flax should not be rippled severely. It is better to leave some of the seed on, than to run the risk of bruising or splitting the delicate fibres about the top of the plant.

The next process is that of steeping, "retting," or watering, which occupies from ten days to a fortnight. The object of it is to dissolve, by means of fermentation, the gummy or resinous matter which holds the woody and the fibrous portions of the stem together. Pure soft water is the best for this purpose, as water impregnated with iron or any other mineral is very prejudicial to the flax. The size of the steeping pool may vary from 6 to 18 feet in breadth, and from 3½ to 4 feet in depth. A series of steeping pools is generally cut near a flowing river, and so arranged as to admit water, when required, at one end of each pool, which should if possible be cut in stiff, clayey soil, as it is the most retentive and the cleanest. An open spot is preferable to one shaded by trees, as the leaves and bark in falling off may stain the flax. The flax should be placed loosely in the pool, in regular rows, rather sloped, with the root ends downwards, and a layer of rushes should be placed immediately above them, followed by tough sods, cut thin, and fitting closely into each other; straw is sometimes substituted for sods. On the top of all some stones should be placed, to keep the flax firmly under the water. As the fermentation proceeds, the superincumbent weight should be increased. As soon as it is found that the woody shore separates freely from the fibre on breaking the stem in two places about 6 inches apart, the fermentation has proceeded long enough, and the flax is ready for removal from the pool, the only proper way of doing this being for the men to stand in the water and carefully hand it out. The system of running off the water injures the colour and quality of the fibre, as it causes the scum and dirt of the pool to settle among the plants. The flax water poisons the river, and destroys any fish that may be in it; but its value as a liquid manure, which contains almost every ingredient that the plant has absorbed from the soil, is attested by the most eminent chemists, and ought to be a sufficient inducement to the farmer to preserve it as the speediest restorative for the flax ground.

The next process is that of "grassing," or spreading the flax, which occupies from a week to a fortnight. Short, clean, and thick meadow land is the best for this purpose, and the flax must be spread evenly and thinly, so as to secure the full benefit of the sun and air. After a few days' exposure, it must be turned with a slight rod (about 8 feet in length and 1½ feet in diameter), so that both sides of it may be bleached alike. When flax is grassed without steeping, as it is in some parts of Germany, the grassing is called dew-retting.

The next process is that of lifting. If the woody part is brittle and breaks easily, separating from the fibre, the flax is ready for lifting, in which great care must be taken to keep the lengths straight and the ends even: and when lifted, the flax should be allowed to dry for a few hours, and then be tied up in small bundles and stacked like grain. All artificial means of drying should be avoided, such e. g. as kiln drying or drying by fire; indeed, exposure to the sun and air in some dry and open position is the only safe system of drying.

The last process to which the flax plant is subjected is that of breaking and scutching, which can be effected either by hand-labour or in a scutching mill driven by water power. In hand-scutching, the flax is first broken by threshing it with a wooden mallet. The sheaf of flax is then opened and spread on the barn floor, the roots all pointing in the same direction. The scutcher, placing his foot on the flax to keep it steady, threshes it first on one side, and then, turning over the sheaf, upon the other, commencing always to thresh at the root end. It is next hung through a niche in an upright board, and is struck repeatedly with the blade of a scutching knife, until the fibre is completely cleaned. The process analogous to threshing by the mallet in hand-scutching is performed in the scutching mills by passing the flax between two rollers, which bruise the woody part of it so completely as to facilitate the after-cleaning. During the latter process a horizontal shaft, with wooden blades attached, performs the duty of the man's arm in hand-scutching; the shaft revolves and the blades penetrate the flax-straw vertically, splitting it, and cleaning the fibre. The more effectually the woody part of the flax is bruised and broken by the rollers, the less time need be spent in exposing the flax to the action of the scutching blades.

The prices realized by hand-scutched flax in the Ulster markets vary from 6*s.* to 9*s.* 6*d.*; by mill-scutched flax, from 7*s.* 6*d.* to 13*s.* 9*d.* per stone of 16¼ lb. The profit per statute acre gained by flax cultivation varies greatly. In some cases it has only been 3*l.*; in others it has reached 15*l.* per acre, after deducting all expenses. The reduction in the price of linen goods during the present century is owing entirely to the improvements that have been effected in the manufacture, and not to any reduction in the cost of the raw material. Any considerable consolidation of farms on the part of Irish landlords must necessarily diminish the supply of home-grown flax. It is essentially the small farmer's crop, sown by himself, and weeded, pulled, steeped, grassed, lifted, and even scutched by his wife and children, for whom these occupations form a light and agreeable kind of hand-labour.

The consumption of flax in the Irish linen manufacture exceeds 100,000 tons per annum, while the entire produce in Ireland has never exceeded 64,506 tons (1864), and it has sunk as low as 12,929 (1871). The largest percentage of acreage under crop in Ireland was in 1864, when the percentage of acreage under flax to acreage under crop generally in that country reached 5·31. The percentage had steadily risen from 1·55 in 1858; but since 1864 it has, with slight fluctuations, been steadily decreasing, the figures being—1865, 4·45 per cent.; 1866, 4·77; 1867, 4·64; 1868, 3·71; 1869, 4·11; 1870, 3·45; 1871, 2·79; 1872, 2·22. The acreage under flax in Ireland in 1864 was 301,693; in 1865, 251,534; in 1866, 263,507; in 1867, 253,257; in 1868, 206,446; in 1869, 229,178; in 1870, 194,893; in 1871, 156,883; in 1872, 122,003. The acreage under flax, however, is not always an accurate guide to the produce, the yield per acre varying considerably in different years. Thus in 1853 the yield per acre rose as high as 40 stones, 3 lb., while in 1871 it sank as low as 13 stones, 3 lb. In 1871, 156,883 acres produced only 13,612 tons of flax, while in 1872 122,003 acres produced 18,920 tons. Thus, while the total acreage diminished 22·23 per cent., there was an increase in the aggregate production of 38·99 per cent. The acreage under flax in England is very small, and has shown a tendency also to decrease. In 1870 there were 22,354 acres under flax in England; in 1871, 15,949; in 1872, 14,011. A similar declension is observable in Wales, where the acreage under flax is also very small. In 1870 there were 204 acres under flax in Wales; in 1871, 175; in 1872, 84. In Scotland there were 1399 acres under flax in 1870; in 1871, 1244; in 1872, 1262.

Parliament, in the earlier part of the present century, gave an annual grant of 9250*l.* to encourage the growth of flax in Ireland. The grant ceased in 1828. A grant was subsequently made for the same object to the "Joint Flax Committee," formed in 1864 of the Royal Dublin Society and the Royal Agricultural Society of Ireland; but it was withdrawn, and the "Joint Flax Committee" ceased to exist in 1871. The Royal Flax Improvement Society of Ireland was established in 1841, under the patronage of Her Majesty and Prince Albert. The Lord Lieutenant of Ireland was Vice-patron, and the Marquis of Downshire, President. A staff of instructors was paid by the Government to visit various parts of the country, and give advice gratuitously to landowners and farmers on the best method of cultivating flax. In 1849 the Queen and Prince Albert visited a Flax Exhibition held at Belfast, from which the Prince is thought to have derived the idea of the London Exhibition of 1851. The Royal Flax Society of Ireland ceased to exist in 1859. Its place has recently been taken by the Flax Supply Association for the Improvement of the Culture of Flax in Ireland, formed on the model of the Cotton Supply Association of Manchester, and presided over by leading linen merchants. It appropriates 200*l.* per annum to the distribution of prizes for skill in the culture of flax.

While the Irish farmer continues dependent on foreign countries for a supply of flax seed, the importations of that commodity into Ireland will be viewed with interest. In 1872, 41,105 Riga barrels (containing 3½ bushels apiece), and 8125 Dutch hogsheads (containing 7 bushels apiece), together with 6682 English sacks (containing 4 bushels apiece), were imported into Ireland. The total amount imported from England and abroad was 227,470 bushels, only about one-half the quantity imported in 1871.

The supply of flax from the home markets being totally inadequate to meet the demands of the linen trade of Ulster, the merchants and manufacturers of that province turn with anxious eyes to the flax producing countries of Europe and Africa. The estimated production of flax in Russia in 1868 was 193,000 tons; in 1869, 300,000 tons. In Holland there were in 1869, 66,272 statute acres under flax, producing 13,921 tons; in 1870, 60,520 statute acres, producing 8918 tons. In Belgium there were in 1866 (the latest date with respect to which we possess authentic data) 142,612 statute acres under flax, producing 29,582 tons. In Prussia, prior to the same date, there were throughout the eight old provinces, 346,300 statute acres under flax. In Austria proper there were in 1871, 253,730 acres under flax, producing 44,523 tons. In Hungary the yield was 18,150 tons. The average acreage appropriated to the growth of flax in France is 160,550 statute acres; the falling off since 1865 is 103,087 acres.

Egypt has attracted the notice of the Flax Supply Association of Ireland in recent years. About 15,000 acres are sown with flax in Egypt every year.

The reader who is desirous of acquiring some information respecting Chevalier Claussen's method of producing flax-cotton from flax, is referred to the article "Flax"* in the 'Encyclopædia Britannica,' where will also be found à description of M. Schenck's method of "retting" flax by means of immersion in water, heated to 80° or 90° Fahrenheit, for sixty or seventy hours. Neither of these methods is now much in use.

* The best authority on the subject of "Flax" is a little work by Mr. William Charley, of Seymour Hill, Belfast, published by Bell and Daldy, of London.

LINEN.

By W. T. Charley, D.C.L. (Oxon.), M.P.

Before describing the various processes by which the flaxen fibre is manufactured into linen, it may not be uninteresting to trace, as briefly as possible, the history of the linen trade. Flax is first mentioned, in connection with Egypt, in Exodus x. 31, and linen in Genesis xii. 42, Joseph, on his appointment to be viceroy of Egypt, being "arrayed" by Pharaoh in "vestures of linen." Job, who is generally supposed to have lived before the Mosaic era, complained that his "days" were "swifter than the weaver's shuttle." (Job vii. 6.) The accuracy of these allusions may be tested by the traveller in Egypt at the present day. The cultivation of the flax plant, the various processes for separating the fibre and dressing it, and the subsequent operations of spinning and weaving into linen fabrics, are depicted, with artistic skill, upon the temples and tombs of Egypt, as freshly as if they had been limned but yesterday, instead of 4000 years ago. The nations of antiquity which, next to Egypt, were famed for the products of their looms, were Phœnicia, Babylonia, Colchis, Greece, Italy, Germany, Gaul, and Spain, the four last-named being also flax-producing regions.

After the fall of the Roman Empire, the linen manufacture underwent a long eclipse. Its reappearance, in the tenth century, was mainly due to the Flemings. In this century the town of Ypres, in Flanders, was built, and soon became celebrated for its manufacture of table-linen, now called "diaper," i.e. "d'Ypres." As early, however, as the seventh century, ladies of rank in England, and even Royal Princesses, had acquired much fame by their skill in spinning, weaving, and embroidering rich vestments for the Anglo-Saxon clergy. After the Norman Conquest there was a constant immigration of Flemish weavers into England. The weavers soon became so important a part of the body politic, that they were incorporated into guilds by Royal Charter. The first mention of *Irish* linen occurs as far back as the thirteenth century; but it was not until the close of the seventeenth century, that it received the impulse which led to its becoming the staple industry of Ulster. The extension of the Irish woollen trade excited the jealousy of the English woollen manufacturers, and in the reigns of Charles II., William III., and Queen Anne successive enactments were passed by Parliament, prohibiting the export of woollen manufactures from Ireland. The Irish woollen trade was ruined, but its ruin was the principal cause of the rapid growth of the linen trade of Ulster. The competitors of the Irish linen manufacturers were to be found, not in England, but in France and Flanders: the English statesman, therefore, had every motive for encouraging the Irish linen trade. The bigotry of a French monarch was, next to the ruin of the Irish woollen trade, the cause of the prosperity of the linen trade of Ulster. The

Huguenots were the most industrious portion of the population of France, and their skill in the industrial arts enriched the nations that received them. A number of French refugees settled in the neighbourhood of Lisburn after the revocation of the Edict of Nantes, who were skilled in the manipulation of flax and in the manufacture of linen. The most noted of these exiles was M. Louis Crommelin, of St. Quentin, who was appointed by the British Government, "Director of the Linen Manufacture of Ireland." His descendants, the Delacherois Crommelins, are numbered amongst the county families of the Northern Province of Ireland at the present day.

A Board was established in Dublin, called "The Trustees for the Linen Manufactures," A.D. 1711, the business of which was to encourage the linen trade of Ulster by the judicious distribution of a Parliamentary grant, which, commencing at 6000*l*. per annum, soon rose to 20,000*l*. per annum. Bounties were given for the increase of the growth of flax and the skilful preparation of the fibre; for improvements in the implements used in dressing it; for the distribution of flax seed; and for the production of superior qualities of yarn and cloth. The Board of Trustees continued to exist for one hundred and seventeen years. The Royal Flax Improvement Society was founded in 1841, and existed for eighteen years. Its place has recently been ably filled by the Flax Supply Association of Belfast. A Board of Manufacturers was established for Scotland, A.D. 1727, for the distribution of similar bounties, pursuant to the Act of Union. Of the 6000*l*. paid to the Scottish Board, 2650*l*. was appropriated to the encouragement of the linen trade. Its first act was to give orders for the establishment of schools all over the country, but especially in the Highlands, for instruction in the art of spinning at the wheel. The fluctuations of the linen trade in Scotland afford a curious illustration of the fact that wherever the manufacture of cotton has progressed, that of linen has declined. Thus, out of 2,103,000 yards of linen stamped in Scotland in 1727, Lanarkshire contributed 272,000; out of 36,268,000 yards of linen stamped in Scotland in 1822 (the year before the abolition of the Scottish Board of Manufactures), Lanarkshire contributed 22,869. The number of yards stamped in Forfarshire rose, during the same period, from 596,000 to 22,629,000 yards. The cotton trade being introduced into the West of Scotland, the linen trade emigrated eastward, Glasgow becoming the capital of the cotton industry, while the linen industry became the staple of Dundee. If Ireland had her Louis Crommelin, Scotland had her Nicholas d'Assaville, also a native of St. Quentin, whom the Scottish Trustees invited over, with a little colony of weavers, immediately after the erection of the Scottish Board. The place where this little colony of French Protestants settled was called "Little Picardy," and it is known at the present day as "Picardy Place."

The Linen Hall in Dublin was the spot to which the Irish linen merchants formerly resorted to sell their linen fabrics. The introduction, however, of steam communication between England and Ireland put an end to this centralized system. Irish merchants went over to London and Manchester, and appointed agents there for the sale of their goods. It is, however, the custom of many English buyers at the present day to go over to Belfast, instead of Dublin, to make their purchases on the spot.

Lisburn Brown Linen Market was formerly a famous emporium for the sale of brown linen. The hand-loom weavers purchased the necessary yarn, wove it at home into cloth and brought the work to market, where it was purchased by the merchants and bleachers or their agents. Brown linen markets existed in many of the principal market towns of Ulster as well as in Lisburn. Seal-masters were appointed by the Irish Linen Board, who inspected the brown linen cloths and affixed their seals to it; and if it was found imperfect after having been "sealed," the buyer could recover compensation from the seal-master, who had his remedy against the weaver. Now, however, this system is wearing out. Instead of petty dealers there are extensive manufacturers, buying from the spinners linen yarn, and each weaving by power-loom a quantity of cloth equal to the produce of one of the old markets. The linen mills of Belfast have contributed greatly to the enormous increase of the population of that thriving community. It is now the second town in Ireland in population, and the first in the number of its parliamentary electors.

From the period of the introduction of the cotton manufacture into England, in the early part of the seventeenth century, down to the year 1773, the weft, or transverse threads of the web, only, were of cotton, the warps or longitudinal threads being wholly of linen yarn. The invention of the spinning jenny in 1767 and of the spinning frame in 1770 obviated the necessity of using linen yarn for warp. Since 1773 calicoes and other cotton fabrics have been made wholly of cotton, and King Cotton has reigned supreme in England. The linen trade has, however, firmly established itself in Leeds, where the splendid flax mills of the Marshalls rival those of the Baxters of Dundee and of the Mulhollands of Belfast. Indeed Yorkshire as long ago as 1838 possessed 91 flax mills, of which 40 were situated in Leeds. In 1862 the flax factories of England employed 20,305 hands; of Scotland, 33,599 hands; and of Ireland, 33,525 hands. The number of spindles in England was 344,308; in Scotland, 279,385; in Ireland, 592,981.

Power-loom weaving was first thought of in 1678 by M. Gennes, a French naval officer; it was applied to the weaving of cotton yarn by the Rev. Dr. Cartwright, a Church of England clergyman, in 1785; but it was not till the year 1812 that the first really successful manufactory for weaving flaxen yarn by power was established by Messrs. Charles Turner and Co., of Limehouse, London. In 1821 power-loom weaving of flaxen yarn was introduced into Scotland; but it was not firmly established in its present great Scotch emporium, Dundee, till 1836, when Messrs. Baxter, Brothers, and Co., who now employ more power-looms in the manufacture of linen fabrics than any other firm in the world, built a linen factory containing 216 power-looms. Belfast contains many splendid power-loom linen factories; and as long ago as 1859, there wer-

3633 power-looms at work in Ireland upon the manufacture of linen fabrics. There are many circumstances which would seem to indicate that, while the days of progress in power-looms have unquestionably set in, those of decadence in hand-looms give warning of approach.

The various subjects connected with linen fabrics naturally divide themselves into four heads: *spinning*, *weaving*, *bleaching*, and *printing*. The first process in the *spinning* mill is the *rough sorting*. This is done by the hand, and the handfuls (or "pieces," as they are called) weigh about one-eighth of a pound each. The finer flax is then subjected to a process of cutting, which is omitted in the case of Riga flax intended for coarse yarns, low-priced milled Irish, and all hand-scutched flax. The *cutting machine* contains a circular saw, about 20 inches in diameter, constructed of three or four plates of steel, each about a quarter of an inch thick, and armed with angular teeth projecting from their circumference. This circular saw revolves with considerable velocity. A boy grasping a handful of flax firmly at both ends passes it between two pair of grooved pulleys, which revolve slowly on either side and carry it against the saw, which tears off first the root end and then the top of the stem from the middle. The flax is thus divided into three lengths: the coarse and strong root ends, the fine and strong middle, and the still finer but less strong tops. The three lengths are collected into separate heaps, "stricks," or "locks," of which there are 300 or 400 to the cut.

All kinds of flax are subjected to the process of *heckling*, or *hackling*. Flax may be either hand-heckled or machine-heckled. The operation of hand-heckling requires much experience in order to attain dexterity. The first tool used by the workman is the "ruffer," which is a rude kind of comb, consisting of a tin-covered stock of wood three-quarters of an inch thick, studded with iron or steel teeth. Each tooth is about a quarter of an inch square at the base, and 7 inches long, and tapers to a fine point. The stock is screwed to a board a little broader and some inches longer than itself, which again is fixed to the heckler's bench slantwise, the points of the teeth inclining from the heckler. A sloping board, at a still greater inclination, is placed behind the teeth, to prevent the flax from entering them too far. The heckler grasps one of the handfuls of flax by the middle, spread out as flatly as possible, between the forefinger and thumb, and winding the top end about his right hand to prevent it from slipping, he proceeds by a circular sweep of his hand to lash the root end of the flax into the teeth of the ruffer, commencing as near the extremity as possible, and gradually working up to his right hand, collecting now and then the fibres by holding his left hand in front of the ruffer and turning the flax from time to time. When the heckler has ruffed the root end, he seizes the flax by the part that has been ruffed, and proceeds in a similar manner to ruff the top end. As it is impossible to ruff entirely up to the hand, there must, of necessity, be a certain space left to be subsequently passed through the ruffer; this is called the "shift"; but the less length that is required for this purpose the better. The next tool used by the workman is the "common eight," which is similar in form to the ruffer, except that the pins are much closer placed and are not more than 5 inches long. The flax is not wound round the hand, but is laid upon the back board with the left hand, over the points of the pins, a slight lowering of the right hand and the angle of inclination of the instrument causing it to enter the pins sufficiently on being drawn forward. From the "common eight" the flax can be taken to other tools, called the "fine-eight," the "ten," the "twelve," and the "eighteen," to be still further heckled.

The object of this process is to split the filaments of the flax into their finest fibres arranged in parallel order, and, so to speak, combed. The flax is divided by this process into two kinds of fibre, called the "line" and the "tow." The longer fibres (or "line") remain in the hand of the heckler as he proceeds; the shorter fibres (or "tow") adhere to the teeth of the instrument, and require to be removed from time to time. In the hands of an unskilful operative the best flax will all be converted into tow. A good heckler feels at once the degree of resistance, and draws the flax with suitable force and velocity, and throws it more or less deeply among the teeth, according to circumstances. It was thought at one time that the requisite delicacy of manipulation could only be secured by manual dexterity; and even after the introduction of machine spinning, hand-heckling was solely employed. The progress of invention has, however, in recent years enabled the spinner to substitute, to a very large extent, machine for hand-heckling. The flax, divided, as previously mentioned, into stricks, is spread out and placed between a pair of short iron bars, which are screwed together and hold it firmly, like the hand of the heckler. Each pair is called a "holder," the screws of which are $4\frac{1}{2}$ inches apart. A number of these holders are fixed to a cylinder at distances a few inches apart. The root ends of the flax fall upon an inner cylinder covered with sharp teeth, which revolves slightly and heckles the flax, while the outer cylinder revolves slowly in the opposite direction. When the holders have passed through about half a circle, they are deposited by the outer cylinder upon a kind of rail. The machine minder, generally a girl, then removes them to another machine similar to the first, where the uncombed ends fall upon an inner cylinder, and are heckled like the ends previously combed. Sometimes the entire process is performed by one machine, the holders being opened by the machine minder, after the root ends have been heckled, and the flax turned the other way. To cleanse the points of the heckling teeth from tow, a series of brushes, fixed upon wooden cylinders, are provided; these brushes pass between the points and remove the tow. One of the best heckling machines is Ardell's intersector, in which two heckling cylinders operate upon the strick of flax, and heckle it on both sides at the same time. Combe and Company, of Belfast, have achieved a great reputation by their various heckling machines. Their self-acting sheet machine is very suitable for heckling the coarser kinds of flax. The heckles are placed upon a flat surface, or "sheet," as the cylinder is not well adapted for heckling large uncut flax. The nature of the operations in the "circular" and "flat" machine is the same, except that in the "circular" the flax is acted on by heckles fixed on the circumference of a cylinder, and in the "flat" by heckles fixed on an endless sheet.

The appearance of the flax after heckling is much changed: the line consisting of long, fine, soft, and glistening fibres of a bright silver grey, or yellowish colour, and when seen from a short distance having very much the appearance of silk.

The next operation is called *sorting*. The heckled flax is taken to the sorting room, where the stacks are separated into various divisions, according to the degrees of fineness. Before the line-sorter is placed a kind of table, containing a number of boxes for receiving the various qualities of line. These boxes are respectively labelled 2 lb., 3 lb., $3\frac{1}{2}$ lb., 4 lb., 5 lb., $5\frac{3}{4}$ lb., $6\frac{1}{2}$ lb., &c., from an old system of comparing fineness with weight. He judges of the various degrees of fineness by the touch, as well as by the eye. A block heckle stands on the table, through which he frequently draws the line, to keep the fibres parallel.

The next operations are those of *spreading and drawing*. Each of the stricks of flax is subdivided into two or three portions, which are arranged longitudinally on the creeping sheet (or feeding cloth) of a spreading machine, the ends of the successive portions overlapping each other about three-fourths of *their* length. The flax is then drawn forward through a part of the spreader called the gill frame (from the French word "aiguilles," needles), and deposited in the form of a ribbon, called a "sliver," into a tall can, capable of holding 1000 yards. Long flax is drawn out to sixty times its original length, cut flax to twenty times. The gill frame comprises (1) a set of rollers, called the holding (or back) rollers, which deliver the flax to (2) another set of rollers, called the drawing rollers, which move at greater speed than the others, increasing the length and diminishing the thickness of the flax. Between the two sets is (3) a set of screw-gills, composed of separate bars or rods, called "fallers," armed with closely ranged ranks of steel needles. These create a friction among the fibres of the flax similar to the action of the fingers in hand-spinning, restraining and regulating the drawing of the fibres by the drawing rollers, and preventing the sliver from being lumpy and irregular. The movement of the fallers is spiral. The flax passes from the drawing rollers to (4) another set of rollers, called the delivering rollers, which deposit the sliver in the can. Between these two there is (5) a plate of metal, having diagonal openings at an angle of 45° to the original course of the sliver, in order to enable it to be turned in a rectangular direction and be guided to the delivering rollers: this plate is called the doubling bars, having been at first made of separate bars.

When the can is full, it is taken to the drawing frame, where eight slivers are combined, and drawn out into one length equal to the sum of their united lengths. The effect of this is to produce great uniformity in the ribbon, the second drawing correcting the defects in the several slivers by equalizing the fibres throughout the whole length. There are, generally, three drawing frames, to which the flax is successively taken. At the second, twelve slivers are drawn into one; at the third, fifteen are drawn into one. The machines for these drawings, though in principle essentially the same as the spreader, differ in some of their minor details, such as having no creeping sheet or feeding cloth, as the sliver has sufficient coherence to be drawn direct from the cans by the back rollers of the drawing machines.

From the drawing frames the slivers are taken to the roving frame, the last operation preparatory to spinning. It is similar to the drawing frames in the arrangement of its back and front rollers and gills; but for the purpose of twisting the sliver into a rove, or loose thread, a flyer is added, and for the purpose of winding the rove preparatory to spinning, a bobbin is added. As the diameter of the bobbin is continually increasing by the accumulation of the rove, while the speed of the front roller is always the same, the speed of the bobbin is nicely regulated so as to diminish in proportion as its diameter increases. The revolution of the bobbin is consequently a continually retarded motion.

The preliminary processes through which the line passes after it is heckled and before it is spun are termed, collectively, *preparing*. The rove-bobbins are now taken to the spinning room. *Spinning* consists in drawing the roving down to the last degree of tenuity desired, and twisting them into hard cylindrical cords, which are called yarns. The spinning of flax does not differ essentially from the spinning of cotton on the "throstle" principle. Mule-spinning, which is so well suited for a weak material, like fine cotton, is not suited for the strong fibre of flax. In hand-spinning, the housewife used to moisten the fibres with her saliva, to make them adhere to each other, and also to make them more pliable and easy to twist; and in imitation of this practice, the fibres were wetted in cold water previous to being spun by machinery. For cold water, water heated to a temperature of 120° is now substituted. This has been found to be a great improvement: a given weight of flax can be spun to double the length that it formerly could, and the thread that is produced is finer, smoother, and more uniform in texture than formerly. The hot water is contained in a trough which runs the whole length of the spinning frame. A dewy spray is continually thrown off by the machinery, against which the attendants protect themselves by waterproof aprons. Probably line which, when spun dry, would produce only 20 leas of yarn, would, when wetted, yield 70 leas or more, and be proportionately more remunerative.

Throstle-spinning is supposed to be derived from the humming sound of the spindles when working at full speed, which, in the most approved machines, is at the rate of 5000 revolutions in a minute, each spindle producing twenty-seven hanks per week. The roving is twisted into yarn by the twirling of the spindle. The three rollers deliver the roving, attenuated to a proper degree of fineness, through a guide eyelet, vertically, to the spindle, and in its progress from the front roller to the nozzle of the spindle, the roving receives the requisite twist, which is communicated to it by the rapid revolution of the spindle. It is thus drawn and twisted into yarn consecutively; and not only so, but it is also wound upon the bobbin before it quits the machine. The hollow fork of the flyer, to which the roving is delivered through the nozzle of the spindle, transmits it directly to the bobbin, which is stuck so loosely upon the spindle that it is not affected by the revolution of the latter; but the roving being pinched by the front roller, is kept fully on the stretch, and the rotation of the bobbin is caused by the drag of the roving. The roving, or, as it should now be termed, the yarn, is equally distributed over the bobbin by the up-and-down motion of the latter along the spindle. This up-and-down motion of the bobbin is communicated to it by the rotation of a disc, causing a weight suspended from a lever to rise and fall. The bobbin rests upon a copping rail, which is made fast to a bar connected by a rod with the lever. When the copping rail rises and falls, the bobbin rises and falls with it. The weight of the bobbin and its friction upon the copping rail, which is promoted by covering its lower extremity with wash-leather, cause it to hang back, and thus the yarn is wound on the bobbin more slowly than the spindle revolves. The retardation regulates itself according to the diameter of the bobbin by the drag of the yarn. Hence the throstle-frame is a much simpler contrivance than the roving frame, where the sliver has too little cohesion to bear the strain put upon the yarn in the throstle-frame, and where it is therefore necessary to give the bobbins that independent motion which so complicates the machine.

The next operation is called *reeling*. The bobbins are conveyed from the throstle-frame to the reeling room, where the yarn is unwound from the bobbins and measured on reels, the lowest denomination being the "lea," or "cut." The standard lea contains 300 yards. The next higher denomination is the "hank." Each hank contains 10 leas, or 3000 yards; 20 hanks contain consequently 60,000 yards; and these constitute one bundle. It is by the standard lea of 300 yards that the description of yarn is known. Thus, "No. 20" contains 20 leas per lb. weight. The bundles are arranged in bunches, containing 3, 6, 9, or 12 bundles apiece, according to the fineness of the quality.

The *drying* of the wet-spun yarn is effected either by steam heated up to 90° Fahr. in lofts, or by exposure in the open air upon poles.

When brought from the drying, the yarns are *made up*, so as to feel soft and supple, by twisting them backwards and forwards and stretching them. They are then folded and are ready for sale.

At the Exhibition of 1851 yarn was shown, spun by an old woman of eighty-four, a native of Ireland, containing 760 leas per lb. weight. Hand-spun yarn from the Continent is still used for very fine cambrics; but in general mill-spun yarn has superseded hand-spun.

Thread, in its technical sense, is the compound cord produced by doubling and twisting two or more single lines of yarn. The thread-frame closely resembles the throstle-frame used for spinning linen yarn, but the water-troughs are smaller, and there are only two rollers, which are placed one above the other. The lines of yarn delivered by the bobbins (which are set closely upon their respective skewers on a creel, or shelf, extending along the whole length of the machine) descend over a glass rod into the water-trough, where they get wetted. On emerging, they are guided along the bottom of the under roller, and, passing between it and the upper roller, turn round the top of the latter, whereon they are laid parallel. From the upper roller the parallel lines of yarn pass obliquely downwards, through an eyelet-hole, to the flyer of the spindle, the rapid revolution of which twists them into a solid cord or thread. The thread then works itself upon the bobbin, which is fitted, as usual, on the spindle.

Passing from the subject of spinning the fibre into yarn to that of *weaving* the yarn into linen cloth, our attention is first called to a series of processes, called *warping*, *sizing*, *beaming*, and *drawing in*, necessary for the purpose of preparing the yarn, or more correctly speaking, the warp, for the weaver.

Weaving is the art of manufacturing yarn into cloth by interlacing together the warp and the weft at right angles to each other. The warp consists of the harder and more twisted lines of yarn, which run longitudinally from end to end of a web of cloth. The weft consists of the softer and less twisted lines of yarn, which run crosswise from selvage to selvage of a web of cloth, at right angles to the warp. The object of *warping* is to arrange all the longitudinal lines of yarn, or warps, evenly, alongside of each other, in one parallel plane. The bobbins, filled with the yarn intended for warps, are taken to the warp-mill, and placed in the warping frame, called a "travers." One-sixth of the number of bobbins, that will furnish the quantity of warp required for the length of the intended web of cloth, is usually mounted in the warping frame. The bobbins are set loosely in a horizontal position, upon wire skewers or spindles attached to the frame, so that they may revolve and give off the yarn freely. The principal machine in the mill is the warping mule, which consists of a large reel of wood with twelve, eighteen, or more sides, and about 7 feet in height and 6 in diameter. The external framework of the reel is mounted upon a vertical shaft, which rises in its centre. An endless band passes round the lower part of the vertical shaft, and also round a wheel placed at some little distance outside the reel, and worked by a handle.

Standing (or sitting) beside the wheel, the warper turns it round, and causes the reel to revolve on the vertical shaft. The reel can be turned from right to left, or *vice versâ*. The warps, converging to a focus, pass from the warping frame to the reel through a small machine called a "heck-box," which contains one hundred and twenty or more pins, made of finely-polished and hard-tempered steel. There are, in fact, as many pins as there are separate lines of warp. At the top of each is a minute eyelet-hole, through which the line of warp passes in its progress to the reel from the warping frame. The pins are inserted alternately in two separate pieces of wood, either of which may be raised, independently of the other, by means of a small handle below. The heck-box slides up and down one (or in some mills, two) of the upright posts of the warping mule, by a simple contrivance. The top of the vertical shaft is connected with the heck-box by means of a cord, which passes over a pulley at the top of the post. As the reel revolves from right to left, the heck-box is thus gradually raised to the top of it; and when it revolves from left to right, the heck-box is gradually lowered to the bottom. The turning of the handle of the mill therefore unwinds the warp from the bobbins in the warping frame, and winds it spirally up and down the circumference of the reel. The use of the heck-box, with its two separate pieces of wood and their alternate rows of pins, is to divide the warps into two alternate sets of threads, one set for each of the two healds or heddles of the loom. This separation is called the "leas," or "lease," and without it there would be difficulty in weaving the yarn into cloth. The process by which the leas is formed is thus described by Mr. Warden in his learned work on 'The Linen Trade': "In commencing to wind the yarn on the reel, the threads which pass through each of the two pieces of the heck are separated by raising one piece on its slide, and they are then passed, the one portion over and the other under a guide-pin attached to the reel. The other piece of the heck is then raised, and the threads in it passed over another pin in the reel, while those in the other piece go under the same. This process is repeated each time the chain or warp is wound up or down the reel, by which means the whole warp is separated thread by thread, so as to facilitate their alternate arrangement in the heddles of the loom. At the bottom of the reel a few threads are alternately passed together in "pinfuls" over and under two other pins, which enables the weaver by means of an evener or very open reed with a movable top, in each opening of which a pinful of yarn is placed, to spread the warp regularly in winding on the yarn-beam of the loom. Before the warp is taken off the reel, a piece of cord is passed carefully through the yarn, close to the pins, to preserve the separation of the threads, at both ends of the warp, which separation is called the lease. In rolling the warp on the yarn-beam, the weaver begins at the end where it is divided into small pinfuls, and terminates where it is separated into alternate threads. He takes care to preserve the lease perfect throughout the entire weaving of the web by passing two lease-rods between the alternate threads and keeping them there." * It only remains to add that the weaver, as he removes the warp from the guide-pins of the reel, winds it, in the form of a huge ball, round his left hand.

The next process is that of *sizing* the warp, which is subject to considerable tension and friction, and would be very likely to break, if stretched in the loom in the

* 'The Linen Trade, Ancient and Modern,' by Alex. J. Warden, 2nd edition *(1867)*, p. 704.

same state in which it is spun. A dressing of size is therefore given to it, to glue together the minute fibrils of which it is composed, and thus increase its strength, tenacity, smoothness, and elasticity. Warps may be sized either by the hand or by a sizing machine. The size consists of a paste of fine flour, to which a little brine is sometimes added. The method of sizing generally used by the hand-loom weaver is to put the dressing on carefully with hand-brushes, spreading it as evenly as possible over the surface. He then employs a fan for the purpose of drying the warp. Sometimes the weaver has recourse to the more primitive method of dipping the warp into a trough filled with warm size, and then squeezing it, repeating the process until the warp is completely saturated with the size, after which he spreads it out to dry in a field or drying loft. When warps are sized by a machine, the rollers containing them are mounted on a frame at one end of it. The lines of warp pass through a kind of reel to keep them distinct, and then between two rollers covered with felt. The lower roller dips into a trough filled with size, and applies the dressing to the yarn, while the upper one squeezes out the superfluous moisture. The size is rubbed into the fibrils of the yarn, and smoothed over by means of cylindrical brushes, one of them over and the other under the yarn, and moving in an opposite direction to it. The dressed yarn is then dried by being passed over a steam box and subjected to a current of air caused by a revolving fan. In some machines there are several steam boxes.

The next process, that of *beaming*, consists of winding the warp round the warp-beam, better known as the "weaver's beam." The weaver unrolls the bundle of warp-yarn, passes one end of it over two slings attached to the roof, then through a funnel mouth round a series of pegs, then backward and forward over rollers, gradually spreading it more and more open until it arrives near the warp-beam, which revolves upon iron pivots. The weaver stands beside the extended lines of warp, holding in his hand an instrument called a ravel or separator. It is a rude kind of comb composed of a block of wood, into which pieces of cane are fastened. The lines of yarn are passed between the teeth of the ravel, and by this means are distributed evenly over the warp-beam to the width to which it is desired to make the cloth.

The last process preparatory to weaving consists in drawing each separate thread of the warp first through the corresponding loop of the heddles, and then through the teeth (or dents) of the reeds. The warp-beam is suspended by its ends so as to allow the lines of warp to hang down perpendicularly. The heddles are also hung up in front of the warp-beam. The weaver sits in front of the heddles and opens their loops; his assistant sits behind, and selecting the appropriate thread of the warp, delivers it to the weaver, who draws it through the corresponding loop of the heddles. The threads of the warp are then drawn through the teeth of the reed by a hook called the reed-hook, two threads being passed through each reed-split.

Weaving can be performed either by the hand or the power loom. The application of machinery to the weaving of linen has been attended with much more difficulty than in the case of cotton fabrcs, owing to the stubbornness or want of elasticity in linen yarn as contrasted with cotton yarn. Gradually the difficulty is being removed, but there is still room for improvement in the power-loom weaving of linen, and hand-looms sustain their superiority in the production of the finer qualities of cloth.

Mr. William Charley, in his work on 'Flax and its Products,' shows clearly the causes of the decay of hand-spinning and the survival of hand-loom weaving: "A power-loom can turn out about two webs of 60 yards each per week, and one woman can attend to two looms, producing at least four webs a week. This production is probably four times the amount produced by the hand-loom weaver, as four or five yards per day of linen would keep him very busy indeed. This is not equal, however, to the saving of labour in the spinning process. A spindle, though in reality not much quicker than a hand spinning wheel, never tires, and therefore would produce in a week nearly double what a woman could turn off her wheel, while one girl in the mill can attend to 160 spindles. To spin by female fingers the yarn that *Ireland alone* could now produce in her mills would require therefore 1,303,744 women expressly devoted to the task. The enormous saving of expense, and the great regularity of production ensured by mill-spinning, at once made the transition from the hand spinning wheel an unavoidable necessity. The saving by power-looms not being so great, the transition state will likely be prolonged over a lengthened period." *

A brief notice of hand-loom weaving will necessarily, therefore, precede a notice of weaving by machinery.

The European loom consists of seven parts: viz. (1) the exterior framework, (2) the warp-beam, (3) the healds (or heddles), (4) the treddles, (5) the lay or batten, with its reed, shuttle-race, cross-bar, swords, pickers, and picking peg; (6) the shuttle; and (7) the cloth bearer, with its ratchet-wheel. A portion of the warp is stretched in the loom, the remainder being left on the warp-beam, which is fitted into one end of the loom. The lease-rods still remain inserted in their proper places across the warp, to preserve the lease, or separation of the alternate threads. As already described, each thread of the warp, by the process called drawing in, passes through the loops of the heddles: the first thread through the first loop in the first heddle, the second thread through the first loop in the second heddle, and so on alternately, and then the threads pass in couples through the teeth of the reed.

The exterior framework of the loom consists of four upright posts, strengthened by cross-beams at either end. The appearance of the loom, when the warp is stretched in it, closely resembles that of a four-post bedstead. There are two heads (or heddles) in the ordinary loom, consisting of twines stretched between two rods or pieces of board, and looped in the middle, the two healds together containing exactly as many

* 'Flax and its Products in Ireland.' By William Charley, J.P. 1862. Page 97.

twines as there are threads of warp. The two heddles are suspended by cords passing over pulleys attached to the upper part of the framework, and so united by these cords, that when one heddle is lowered the other rises. The cords and pulleys are called the harness. The heddles are worked by means of the treddles, of which there are also two, one attached (by a cord) to each heddle. The treddles are so called, because it is by "treading" upon them that they are put in motion, and communicate that motion to the heddles. The most complicated structure in the loom is the lay, or batten. It consists of a wooden frame, which swings on the upper part of the framework of the loom by its cross-bar. The poising of the lay is a matter of great nicety. It should be hung midway between the heddles and the woven portion of the work; for the greater the space in which it describes its arc, when in motion, the harder is the stroke which it delivers. The size of the lay must depend upon the kind of goods which it is intended to weave: the heavier the fabric, the larger will be the lay, and, indeed, the entire loom. If properly poised, the lay will return to its normal condition by its own weight. The two wooden bars which connect the bottom of the lay with the cross-bar upon which it swings are called the swords, and the size and swing of the lay will, of course, depend, to a great extent, on the length of these swords. In examining the bottom of the lay, the first thing that we notice is the reed. The fineness of the cloth is calculated by the number of dents in the reed, two threads of the warps, as already stated, passing through each dent. A web, called a 10^{oo}, contains 2000 threads of warps in 40 inches wide of the cloth. The reed is set into the bottom of the lay, between the swords, and is shut down into its place by a cap-piece attached to the swords, which the weaver grasps with his left hand, when he pulls the lay towards him in weaving. Prior to the year 1733 the bottom bar of the lay only reached from side to side of the swords. The weaver, bending forward, threw the shuttle with one hand across the "shed," and caught it with the other, then threw it back again, and so on, a very laborious operation. In 1733 John Kay, of Bury, patented the fly-shuttle (so called from its speed), which greatly lessened the labour of weaving, and enabled the weaver to produce twice as much cloth as formerly. The fly-shuttle has now generally taken the place of the old hand-thrown shuttle. The bottom bar of the lay lengthways is made to extend, on either side, beyond the swords, and projects breadthways about an inch and a half in front, forming a kind of shelf or ledge, called the shuttle-race. At the ends of the shuttle-race are thin boards screwed on, to form two troughs or boxes, in which pieces of wood, horn, or thick leather, called pickers, move along wires. These wires are fixed at one end to the swords of the lay, at the other to the end pieces of the troughs. To each picker a string is attached; the two strings being united in a handle, which the weaver holds in his right hand when weaving. The shuttle is placed in one of the troughs, and bears some resemblance to the kind of boat called a skiff. In the centre of the boat is placed a bobbin, containing the yarn that is to be *used for wefts;* and the end of this yarn runs through a small hole in the side of the boat, called the eye. There is, so to speak, no stern to the boat; as it is pulled from right to left, and also from left to right, it has a prow at both ends. It has also two small wheels, upon which it runs swiftly and easily along the shuttle-race. When the weaver pulls the handle of the string attached to the pickers (called the "picking peg"), a momentum is imparted to the shuttle, which drives it across the shuttle-race from right to left; a second pull drives it from left to right. The shuttle should never be driven with violence, as it will recoil, and slacken the thread of the weft.

The woven cloth, as it is completed, is wound upon the cloth-beam by turning a handle at its side, the beam being prevented from slipping by a ratchet-wheel, which takes into a holding tooth.

Having explained the various parts of the hand-loom, it remains to describe the process of hand-loom weaving. The weaver sits on a bench at the end of the loom, opposite to that to which the warp-beam is attached, and presses with his right foot upon one of the treddles. This lowers one of the heddles, and with it all the lines of warp that pass through its loops, and at the same time raises the other heddle, and with it all the lines of warp that pass through its loops. The interval thus opened up between the alternate sets of warp is called the shed, and the operation of opening it up is called shedding the warp. Into the shed and across the shuttle-race the weaver then projects the shuttle, by pulling the picking peg with his right hand. A thread of weft is thus deposited at right angles to the lines of warp. With his left hand the weaver then pulls the lay towards him, with such force as the closeness of the texture requires. The lay drives the thread of weft close up to the web. The weaver then presses with his left foot upon the other treddle. This lowers the heddle, and with it all the lines of warp that were previously raised, and raises all the lines of warp that were previously lowered. The weaver then, by pulling the picking peg, drives the shuttle along the shuttle-race back to the trough from which it previously emerged, and then "brings home" with the lay. For every thread of weft thrown across the warp, it will thus be seen that the weaver has three successive operations to perform: first, to press upon a treddle with one foot; secondly, to pluck the picking peg with his right hand; and thirdly, to pull the lay towards him with his left hand. The web, as it is woven, is wound, as already described, round the cloth-beam by the weaver, who thus unwinds the warp from the warp-beam at the same time. The proper degree of tension is preserved by weights, suspended by cords from the warp-beam; and the cloth, when woven, is kept from contracting in breadth, through the shrinking of the warp, by means of two pieces of hard wood bound together, the extremities of which are armed with sharp points, which pierce the selvages of the cloth, and thus keep it distended. These are called temples.

This description, somewhat minute, of the hand-loom will facilitate the acquisition of a knowledge of the mechanism of the power-loom. All the various parts of the hand-loom are reproduced in the power-loom, plus the machinery moved by steam, which is substituted for the hands and feet of the weaver. The framework of the power-loom is made of cast iron, and comprises side uprights bound together by cross-beams. The sides are also connected together by a large arch, which, springing from them, surmounts the rest of the loom. There is a breast-beam at the front, over which the cloth passes on its way to the cloth-beam; and there is a roller at the back, over which the warp passes in its progress from the warp-beam. The plane of the warp is thus preserved in a horizontal position during the process of weaving. The breast-beam is nearly square, but its upper surface is sloped a little towards the front, and its edge rounded off to enable the cloth to glide smoothly over it. The heddles are suspended (by cords and pulleys, as usual,) from an iron shaft connected with the arch which binds the sides of the framework together. The motion of the treddles is produced by two eccentric wheels (or tappets) acting on the two treddles or levers furnished with friction rollers, the short radius of one wheel allowing its corresponding treddle to be raised, at the time that the long radius of the other wheel depresses its treddle; thus the treddles are raised and depressed alternately. The stroke of the lay (or batten) which drives home the weft is produced by two cranks, one at each side of the loom, close by the framework. The shuttle is thrown by a whip-lever in the centre of the loom, moving alternately to the right and left. To this the picking cord is attached, and is plucked either way with a jerk, which propels the shuttle along the shuttle-race. Some looms have two whip-levers, one at each side. Motion is communicated to the lay, shuttle, and treddles by means of wheels, cranks, pulleys, and bands connected with the driving shaft of the factory. The mechanism for throwing the loom out of gear and stopping it is simple. There are two pulleys (or riggers), one fast, connected with the steam shaft of the factory, the other loose, unconnected with it. When the driving band is upon the fast or innermost pulley, the loom is in gear with the steam shaft. The weaver can stop the loom by moving a lever, which is affixed to one of the side uprights of the framework at its lower end, from left to right. The upper part of the lever (which is worked by a handle), by falling into a notch in a small bearing attached to the frame, is held at a sufficient distance from the side upright to throw the band in a lateral direction off the fast pulley upon the outer or loose one. The connection of the loom with the steam shaft is thus severed, and the machinery is instantly stopped.

The linen, whether woven in a hand or a power loom, is, of course, brown, and I have already described the method of disposing of hand-made linen formerly at the Brown Linen Markets of Ulster. Armagh, Ballymena, Coleraine, Ballymoney, and Lurgan, are still markets for the sale of brown hand-woven linens: but power-loom linens are disposed of by the manufacturers, privately, to the buyers. Brown linens not sold in the brown state are sent to the bleacher to be bleached and then finished by him, or bleached simply, and then sent to the dyer or printer, to be coloured first and finished afterwards.

I have now a few observations to offer on the third branch of our subject, viz. *bleaching*, which term comes from the French, "blanchir," to whiten. The processes employed for bleaching linen are much more difficult and tedious than those for bleaching cotton fabrics, for it contains much more colouring matter than cotton, and loses nearly one-third of its weight in bleaching, while cotton only loses one-twentieth. There are two systems of bleaching, the old and new,—the distinguishing feature of the former is *crofting*, of the latter, *chemicking*. In both systems *bucking* and *souring* are employed. *Crofting* is a tedious process. The linen is exposed, for two or three days at a time, to the action of the atmosphere, upon the grass in bleachfields. In the North of Ireland the bleachfields, from a distance, with their acres of white cloth spread out upon the hill-sides, look like some Alpine snow-scene. The crofting is repeated at frequent intervals, about half of the time employed in bleaching being devoted to it. *Chemicking* consists in steeping the cloth in a solution of chloride of lime (or chloride of soda). The cloth is placed in stone vats, over the centre of which a perforated trough is suspended. Into this the solution is pumped, and from it pours down upon the cloth. This process is continued for about four hours. The bleaching powder,* in order to be applied to the cloth, must be dissolved in water, in the proportion of about half a

* The manufacture of bleaching powder will be described in another volume by Professor Church.

pound of chloride of lime to three gallons of water. This amount of chloride of lime-steep, or "chemick," will bleach one pound of cloth.

Bucking consists of boiling the cloth in alkaline lye (or in slaked lime first, and alkaline lye afterwards), in huge iron boilers for eight or ten hours at a time. This operation is repeated frequently in the open-air method of bleaching, and is always followed by crofting. *Souring* is the process of steeping the cloth in water mixed with sulphuric acid, in the proportion of 8 gallons of the latter to 200 of the former. The "sour" was originally composed of butter-milk: hence its name. In the "sour" the cloth is allowed to remain for about ten hours, and is rendered much whiter than it was before. As the acid corrodes if allowed to remain in the cloth, every trace of the acid requires to be removed by very careful washing. Besides whitening the cloth, the sour removes the lime and alkali. Mr. William Charley enumerates no fewer than twenty-two operations (or, including the intermediate washings, forty-four operations) for "bleaching one parcel of light linens, say 150 double pieces," exclusive of beetling and finishing:

		Mins.	Days.
1. Steep for twenty-four hours ..	Wash	15	2
2. Boil for seven hours in lye and rosin, $2\frac{1}{2}°$	"	15	1
3. Boil for nine hours in lye, $2\frac{1}{2}°$ ..	"	30	1
4. Grass for three days		..	3
5. Boil for ten hours in lye, 3° ..	"	30	1
6. Grass for three days		..	3
7. Boil for eight hours in lye, 3° ..	"	30	1
8. Grass for three days		..	3

		Mins.	Days.
9. Rough sour for ten hours in vitriol, 2°	Wash	40	1
10. Scald for four hours in weak lye	„	30	1
11. Grass for two days		..	2
12. Dip for ten hours in alkaline (40 to 1 strength)	„	30	1
13. Sour for twelve hours in vitriol, 1½°	„	45	1
14. Scald for four hours in lye and soap	„	20	1
15. Rub with brown soap	„	35	1
16. Grass for two days		..	2
17. Dip for ten hours in alkaline (30 to 1 strength)	„	20	1
18. Sour for twelve hours in vitriol, 1°	„	45	1
19. Scald for three hours in soap and lye	„	30	1
20. Dip for ten hours in alkaline (45 to 1 strength)	„	20	1
21. Sour for twelve hours in vitriol, 1°	„	45	1
22. Rub with soap	„	20	1

This may be termed "the open-air process," thirteen days out of the thirty-one employed, it will be seen, being devoted to the operation of "grass-bleaching," for which the climate of Ireland is particularly well suited.

Mr. Hunt, in his sixth edition of Dr. Ure's 'Art-Dictionary,"* speaks of this as "the old method," which has been superseded by the following new method, occupying a much shorter time:

1. Wash.
2. Boil in lime water ten or twelve hours.
3. Sour in muriatic acid of 2° Twaddle for three, four, or five hours.

* Published in 1867.

4. Wash well.
5. Boil with resin and soda-ash twelve hours.
6. Turn the goods, so that those at the top shall be at the bottom, and boil again as at No. 5.
7. Wash well.
8. Chemick, at $\frac{1}{2}$° Tw., or 1002·5, four hours.
9. Sour, at 2° Tw., or 1010 specific gravity.
10. Wash.
11. Boil in soda-ash for ten hours.
12. Chemick again.
13. Wash and dry.

Mr. Hunt speaks of the "old method" as if it had entirely ceased "ten or fifteen years ago," but linen is still frequently "grass-bleached" at the present day. If the linen has to be dyed or printed, it is now removed to the dye or print works in an unfinished state.

It is easier to dye cotton than linen, the flaxen fibre being harder and less absorbent; but neither cotton nor linen can be made to imbibe such brilliant colours as silk and wool. There are two kinds of colours, "substantive" colours, insoluble in water, such as indigo blue, and "adjective" colours, soluble in water, which must be fixed upon the fabric by means of mordants. The mere immersion of the cloth in a soluble dye-stuff will not dye it, for the latter will wash off; therefore the colour must be fixed upon or into the fibre, in a condition insoluble in water. The mordant supplies the "missing link" between the fibre and the dye-stuff. The action of the mordant is to withdraw the latter from a state of solution, and to form with it upon the cloth itself an insoluble compound. Alumina, the oxides of tin, the protoxide of lead, the black oxide of copper, and the infusion of nutgalls are the principal mordants.

Another division of colours is into primary or simple, and compound or mixed. The first named are red, yellow, and blue. To these the author of the elaborate article in the 'Encyclopædia Britannica' on "Dyeing" adds black and brown; but black is not so much a colour as the absence of colour, and brown is also a compound. The principal compound colours are orange, green, purple, and grey. But dyeing and printing have undergone a considerable change through the recent discovery of aniline dyes, which are produced from coal-tar, and include some twenty or thirty new colours,—magenta, mauve, solferino, &c., but as these are treated of in another place, I need only here allude to them.

The colour of the cloth, on its being removed from the dyebeck, will be found to be dull. In order to improve this, it is necessary to employ an "alterant," so called by Berthollet because it "alters" the colour to a brighter shade. The oxide of tin is the alterant used in dyeing Turkey red.

There are other processes connected with dyeing, besides the successive applications of the mordant, the dye-stuff, and the alterant, including scouring, galling, and dunging, which can only receive a passing mention here.

The cloth, after being dyed, is washed, rinsed, starched, dried, calendered, and made up for the *market.*

The printing of linen fabrics was not an extensive business till recently, and the processes are more tedious and expensive than those employed in printing cotton. Nearly all the linens printed in Ireland are sent to the Continent, the United States, the West Indies, or Mexico.

Till the latter end of the last century, linen was printed by the hand, a method still in use for certain styles, and called "block-printing." A great saving of time as well as extreme accuracy of execution have been secured by the invention of printing by machinery, called "cylinder-printing" (or "roller-printing"). The pattern is first sketched on paper. The block in hand-printing is made of sycamore, holly, or pear-tree wood, or of deal faced with sycamore or pear-tree, and is from 2 to 3 inches thick, 9 to 10 inches long, and 5 broad, with a handle of boxwood for holding it by. The pattern is commonly carved on the face of the block; but in finer patterns narrow slips of flattened copper wire are forced edgeways into the wood, following the lines of the figured pattern, and defining it more sharply than can be done in wood-cutting. The interstices between the ridges are, when copper wire is used, filled up with felt-stuff. The principles already enumerated respecting mordants and dye stuffs are applicable to printing as well as dyeing. Those mordants are preferred which are possessed of great solubility; and to give them such consistency as will enable them to dry on a figured pattern, they are thickened to the consistency of a jelly by mixing with them starch, gum, flour, or paste. Four pounds of gum arabic or senegal are sufficient to give consistency to a gallon of liquor. The dye stuff or mordant, as the case may be, is spread by a boy or girl, called a "teerer," or "tearer" (probably a corruption of "*tireur*"), with a brush uniformly over the surface of a piece of superfine woollen cloth, stretched tightly over the head of a wooden drum, called a *sieve*. The sieve floats in a tub of size or thick varnish, fitting into it pretty closely, but not so as to interfere with its elastic buoyancy. The printer presses the face of the block on the drum-head, so that every part of the raised device may acquire an equal and sufficient coating of colour. He then applies the face of the block to the cloth, which is stretched upon a printing-table formed of mahogany, marble, or flagstone with a surface truly plane. It stands on strong feet, its top is about 36 inches from the floor, and it is covered by a blanket stretched tightly over it, and hooked at the side. In extending the cloth upon the blanket, the printer takes care to place the selvage one inch from the edge of the table. The blocks have pin-points fixed into their corners, by means of which they are adjusted to their positions upon the cloth, so that the different parts of the design may be joined together with precision. The printer strikes the block a blow with a wooden mallet, to fully impress the design upon and transfer the colouring to the cloth. The cloth is printed from one end to the other by a constant repetition of this process, a fresh daub of the colouring liquid being taken from the sieve prior to each application of the block to the cloth. The cloth that is to be printed is arranged in folds, and the lengths when printed are drawn over rollers suspended from the ceiling by the printer, to facilitate their drying. A single block prints only a single colour, and if the design contains several colours, a different block will be required for each. The application of the other colours is called the "grounding in," or "re-entering" ("*rentrage*"), of the new colours. The raised parts of each of the blocks correspond with the depressed parts of the others.

The saving of time effected by cylinder-printing may be illustrated by the fact, that to print a piece of cloth 28 yards long by 30 inches broad in three colours, 2016 applications of three blocks, 9 inches long by 5 inches broad, are necessary; while a cylinder machine can print a mile of cloth in four different colours in an hour! One cylinder machine, it is estimated, can print as much cloth as one hundred printers and one hundred "tearers" combined could print by hand in the same time! The pattern is either engraved by hand, or by the method of an American gentleman named Perkins, on the copper roller of the cylinder machine. In the latter case the pattern is first drawn upon a scale of about 3 inches square, and then engraved in *intaglio* upon a roller of softened steel, about 1 inch in diameter and 3 inches long. The engraver uses a lens while engaged in this delicate work. The steel roller thus engraved by the hand is called the "die," and is hardened by heating it to a cherry-red, and plunging it into cold water. It is then put into a rotatory press, called a "clamming machine," when it transfers its design to a similar roller in a softened state, called the "mill," in *relievo*. The mill is hardened and put into a rotatory machine, where it indents upon the copper roller of the cylinder machine the whole of the intended pattern. The copper roller, engraved by hand or by Mr. Perkins's process, is mounted on a strong framework between two other cylinders. One of these, which is placed above the engraved cylinder, is a large iron drum, round which passes an endless web of blanketing, and over that the cloth to be printed. The other cylinder is much smaller than the upper one, though somewhat larger than the engraved cylinder. It is made of wood, and covered with woollen stuff, and is partly plunged into a trough containing the mordant or colouring matter. The engraved cylinder is pressed upwards by weights or screws against the large drum. The wooden cylinder is made to bear against the engraved one, which receives motion by means of wheels connected with the steam or water power of the factory. The web of cloth is carried onward between the large drum and the engraved cylinder, which is coated with the colouring matter by the revolution of the wooden one. The cloth thus receives the impression of the pattern engraved on the copper cylinder. A sharp-edged plate of gun-metal, bronze, brass, and iron alloys, or of steel, screwed between the gun-metal stiffening bars, is slightly pressed, at a tangent, upon the engraved roller, and vibrates with a slow motion from side to side, so as to exercise a delicate shaving motion upon the surface of the copper roller as it revolves. A *similar* plate is pressed very slightly upon the same roller, but it has no traverse motion. The former plate is called the "colour doctor," and its use is to remove the superfluous colouring matter, which falls, as the colour doctor scrapes it off, into the trough beneath. The other plate is the "lint doctor," and its use is to remove any fibres which may have come off the cloth in the act of printing.

The subsequent processes include:

1. Ageing for three days.
2. Dunging.
3. Wincing in cold water.
4. Washing at a dash wheel.
5. Wincing in a solution of dung-substitute and size.
6. Wincing in cold water.
7. Dyeing.
8. Wincing in cold water.
9. Washing at the dash-wheel.
10. Wincing in soap-water containing a salt of tin.
11. Washing at the dash-wheel.
12. Wincing in soap-water.
13. Wincing in a solution of bleaching powder.
14. Washing at the dash-wheel.
15. Drying by the water-extractor.
16. Folding.
17. Starching.
18. Drying by steam.

The cloth is then ready for finishing and making up. The above list of processes is applicable to dyeing red in madder, though somewhat varied, according to the tint that is to be printed. In the "ageing room" the mordant, by exposure to the air, undergoes a chemical change, by which it becomes attached to the cloth in an insoluble state. The process of "*dung-*

ing" is next employed, its object being to remove the superfluous mordant or colouring matter, which would otherwise spread over the surface of the cloth and deface the pattern. This is attained by passing the cloth through a weak solution of cow-dung, contained in two stone cisterns placed end to end, each about 6 feet long, 3 feet wide, and 4 feet deep. The mixture in one cistern is formed with 2 gallons of dung to the cistern full of water, heated to about 160° to 180°. The second cistern contains nearly 1 gallon of dung. The cloth, guided by rollers to keep it free from folds, is drawn quickly through the first cistern and then through the second. The process is necessary for alum, iron, and tin mordants, when applied to the cloth before the dye.

The dye is contained in a vat, through which the cloth is drawn on rollers for two hours and a quarter. The colour attaches itself firmly to those portions of the cloth on which the mordant has previously impressed, forming with the latter a chemical compound. The subsequent wincings in soap and water and in bleaching-powder remove the colouring matter, which feebly adheres to the unmordanted portions of the cloth.

The above plan of dyeing must be considerably varied in case of printing with a substantive colour, such as indigo. A "resist," or "resist paste," as it is called, is printed on the calico in this case, in lieu of a mordant. Its effect is, to prevent those portions of the cloth to which it is applied from acquiring colour, when the cloth is passed through the dyebeck. The portions of the pattern covered by the resist continue white as before, and it leaves a white design on a coloured ground. The same result is produced by the "discharge style," only in a different manner. The discharger is applied after the cloth has been mordanted or dyed, as the case may be, and converts the mordant colouring matter into a soluble product, which is removed by washing. Chlorine and chromic acid are used for discharging a vegetable or animal colouring matter; and an acid solution for discharging a mordant. A modification of this style is the well-known Bandanna style for pocket-handkerchiefs. In the "padding" style, the cloth is mordanted all over in a padding machine (similar to a stocking-machine), and then a pattern is printed on in acid, producing a white pattern on a dyed ground.

If the linen is finished by the bleacher, he first *starches* it, which improves the appearance of the fabric and adds to its apparent strength and thickness. The starch at large bleach-works is prepared by the bleachers themselves, and is composed of flour mixed with indigo, to give it a blue colour, and with such a quantity of water as is necessary to give the cloth the requisite degree of stiffness. Pure starch is not always used, for fine clay, gypsum, Spanish white, or sulphate of baryta is sometimes added to it, to thicken it. The starch is placed in a trough, into which a roller dips and lays it regularly and evenly on the cloth. The other rollers of the starching machine (or stiffening mangle) squeeze out the superfluous starch, which falls back into the trough.

After the cloth has been starched, it is *dried* upon steam-heated iron cylinders, or on elongated frames in a room heated by steam, at a temperature varying from 90° to 110°. A piece of cloth can be dried in about fifteen minutes.

The cloth is now ready for "*finishing*." In the North of Ireland this is almost invariably accompanied by the use of "beetling engines," the roar and rattle of which resound over the bleaching green. The "beetle" consists of a number of wooden stocks falling upon a smooth stone surface. Motion is communicated by means of a horizontal roller behind the machine, from the surface of which project numerous pieces of wood. As the roller revolves, these projections come in contact with corresponding pieces in the stocks, which elevate them to a certain height, when, escaping from the contact, they fall with considerable force and a loud rattling noise upon the cloth underneath.

A "calender" to give finish to bleached linens was erected at Douglasfield, in the parish of Dundee, in 1819, and since then calendering has been applied in Scotland to the finish of almost every class of linens. The cloth is slightly damped before being passed through the calender. The damping machine is fitted with a box, partly filled with water, within which a circular brush revolves rapidly, just touching the surface of the water. The cloth is drawn over the mouth of the box by a pair of rollers worked by machinery. In its progress it is sprinkled by the brushes with a fine spray, which deposits a number of small round wet *spots on* its surface. The cloth is folded by a workman, as it is given out by the rollers; and after having been left in folds for some time the spots disappear, and the cloth acquires a uniform dampness.

The object of *calendering*, or "cylindering," is to impart to the cloth a soft and silky gloss. This is effected by passing it over and under rollers, pressed together with an amount of force, which varies according to the surface texture that it is desired to produce. The rollers are placed one above the other in a massive framework, and consist of cast iron, wood, and pasteboard. The cloth is first wound upon a wooden cylinder, near the ground; it then passes round a hollow cylinder of iron, then round a pasteboard one, then under a massive one of iron, to be finally wound upon a wooden cylinder. The iron cylinder can be heated by steam or by the insertion of a red-hot iron roller. The pressure is applied to the cylinders by pulleys and levers, the motion by wheels and shafts.

The cloth is now ready for *making up*. It is first *measured*, and then *lapped* in various styles, to suit the different markets of the world. Linen for the home trade is generally folded in thick pieces, containing 25 to 30 yards each, and ornamented plainly with fancy ribbons and devices. Linen for export is much more profusely ornamented; tickets, with devices in gold and bronze upon a blue or red ground, are pasted on, presenting a very gay appearance, and mottoes denoting the locality from which the style was derived are impressed upon the cloth or the tickets. These decorations add to the attractiveness, and at the same time to the price of the goods, but not to their real worth. The writer of the article on "Bleaching," in the 'Encyclopædia Britannica,' shakes his head over these "devices;" but Mr. William Charley defends them, on the ground that their signification is well understood. When the goods have been folded and ticketed, they are placed in a hydraulic press, with a sheet of pasteboard between the pieces. After being pressed, they are packed in wooden boxes, generally made by carpenters upon the premises. The boxes are securely nailed down and corded, and the nature of the contents is indicated by somewhat mysterious looking characters painted on the outside.

The cloth is now ready for carriage to its destination, by land or water, or both, as the case may be.

COTTON.

By Isaac Watts, Secretary of the Cotton Supply Association.

The cotton plant is undoubtedly one of the most wonderful of nature's productions. Had its magical uses been known to the progenitors of the human race, they might have found in it a better material than that from which their first garments were fabricated. Though the skins of animals, the wool of sheep, and the hair of goats were early resorted to for the purpose of clothing the increasing millions of mankind, the value of the cotton plant was soon discovered, and has since become the chief material for the dresses of all nations. The fleecy fruit of the wild trees of which Herodotus speaks, has been turned to wonderful account, and the patriarchal art of spinning has received such marvellous development and extension by means of modern inventions, as to make the manufacture of cotton of unequalled importance and world-wide celebrity. The botany and plant history of cotton has ever been a perplexing and difficult question. The proper classification, though it has received much careful attention, and been made the subject of frequent discussions, has not yet by any means been authoritatively settled. Cultivated for its precious qualities for unknown ages, its wild types and their habitats are but little known, added to which the real points of difference are so slight, that the systematic botanist has scarcely ground to go upon in the determination of species and affinities.

This much is certainly known, that there are two great typical divisions between which no doubt can exist as to their real specific difference, to wit, the cottons of the New and those of the Old world. No person at all conversant with botanical observation could mistake one family for the other, and yet we know of but one or two valid reasons for separating them. One is, that the seed of the Asiatic plant is never black or naked; in the next place, the curvature at the base of the leaf-lobes is compounded of two opposite curves, and not purely heart-shaped, as in the case of the occidental plant. The incapability of the two types to interbreed with each other is also significant, and the differences may be summed up by remarking that the stem and branches are slender, and what the botanists call terete or cylindrical, not angled; moreover, as far as is known, the true Indian cotton is never seen with self-coloured blossoms, i. e. wanting the purple blotch at the base of the petals.

Although these two families cannot be intercrossed, yet they breed with facility amongst themselves respectively, and numbers of hybrid or rather cross-bred sorts have been raised by experimenters, which will be afterwards noticed, and which give great promise of substantial improvement in the plant.

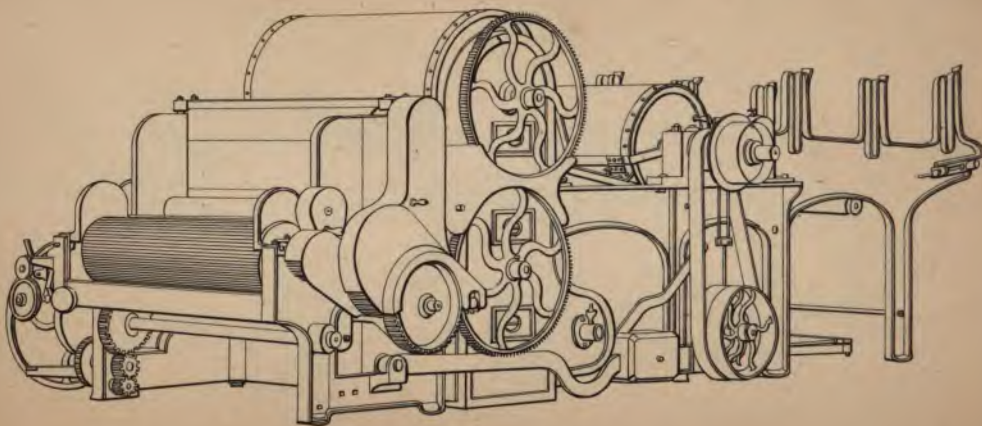
Each of these two types has from long cultivation branched into countless varieties, and each, more especially the American or occidental, affords us at least sufficient material for classing them, if not into species, into very distinct races of permanent character.

Indian Cottons.

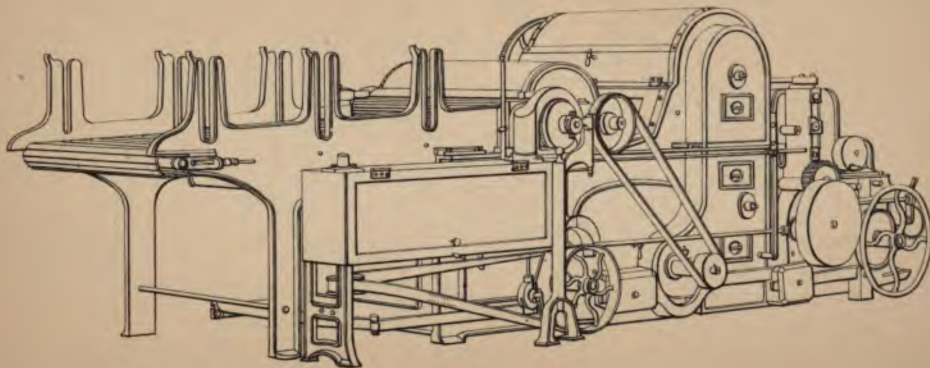
With the exception of the curious purple-blossomed cotton-tree or shrub of the Hindoos, and one or two wild-looking sorts observed by botanists growing uncultivated in Scinde, and also in the island of Ceylon, all the Indian cottons are doubtless much-varied forms of one *Gossypium herbaceum*. At any rate, this is most in accordance with modern botanical ideas. *Gossypium arboreum*, distinguished from every other known sort by its handsome red purple blossom, has been for ages a favourite, and even a reputed sacred plant in India. It is grown and carefully preserved about the Hindoo temples, and furnishes the Brahmins with the sacred tripartite thread, the emblem of the Trinity of their creed. It bears the popular name of Nurmah, or Deo Parati. This species differs from the other Indian cottons, principally by the colour of the flower and that of the seeds, which are covered with rich green down or fuzz, as it is called, resembling in this respect those of the American Uplands. The habit is that of a slender small tree, and the whole plant, leaf and branch, is pervaded by a dusky purplish tinge which is alone sufficient to distinguish it. The cotton is of good quality and the cultivation of it has frequently been attempted, but for some reason or other it has never come into general use.

It would be impossible to particularize the legion of varieties into which the second species, *Gossypium herbaceum*, Indian cotton proper (Surat), has branched. It will be sufficient to name the leading sorts and their peculiarities: to the consumer they are much the same all round, and provided they have been well cultivated, and the staple be clean, are equally acceptable for the manufacture of a certain class of goods. The form best and longest known is that which has also found its way into the warmer parts of Europe, and is to a considerable extent grown in the Levant and Greek islands. This, when mixed with American Uplands, also grown there, forms the staple imported thence under the name of Smyrna. The staple is long (for Indian cotton), rivalling ordinary Uplands in this respect, though the quality is harsher. This is the form to which Linnæus gave the name of *Gossypium herbaceum*, and is considered as the Type, or Varietas Princeps, of the species.

It is to be regretted that the American Uplands, *Gossypium hirsutum*, has been much confused by ignorant persons with this plant under the common name of Herbaceum or Herbaceous cotton. The great drawback to this race of cottons is, that the pod does not upon ripening open itself sufficiently to render the withdrawal of the seeds and fibre a quick or easy operation. The celebrated Dhollera is mainly the produce of this plant. Another fine breed of Indian cottons is known by the names of Broach, Oomrawuttee,



FINISHER LAP MACHINE



LAP MACHINE

&c., which seem to be comprehended under the general name of Jurree. In these the pod opens itself well at picking time, the plant is hardy, the staple tolerably plentiful, and the cotton soft and good.

For the highest qualities the Hingunghât of the Central Provinces and the Berars appears to stand at the head of all. The fibre is fairly long, strong, and white, is beautifully soft and silky in texture, and well adapted for spinning. In districts where this kind will succeed, for it is somewhat delicate in habit, it has no equal. The variety called Bunnee is grown in the same districts and appears to be a hardier and somewhat inferior form of this plant. The North-Western Provinces have their various and peculiar kinds suited to their climate, but none of these are at present comparable with the finer sorts of Central India. There is also cultivated here and there a race of longer lived and more shrubby habit than virtually annual sorts generally grown. The wild or supposed wild forms appear to be of this character.

Two other sorts, of which specimen bales were sent to the Great International Exhibition of 1851, remain to be noticed. One labelled "Cachar" appears to be identical with the cotton usually cultivated in China, bearing rather large pods of a strong harsh cotton; the other, which was sent from the Assamese hills, bears still larger pods and even harsher cotton. This curious and distinct cotton has been again lately brought into notice by the Agri-Horticultural Society of India, and some interesting experiments have been made with a view to its improvement, showing the value in this respect. of hybrid intermixtures. This great coarse curious Assamese sort, which from its extreme harshness is almost useless, when crossed with Hingunghât undergoes an extraordinary change, and becomes a presentable and useful cotton. The improvement to be secured by means of hybridization has scarcely yet been sufficiently tested, but results have already been obtained which show the importance of making still further efforts in this direction.

American Cottons.

The second great division or group of the genus comprises the larger and far more valuable races unknown to the civilized world before the discovery of the Americas. They may be called the Occidental or American sorts, as distinguished from the Oriental, Asiatic, or Indian, as there is no evidence that any of them are of truly Oriental origin, although several of them have from time to time been partially naturalized in India.

They are at once distinguished from the Old world species by their large and luxuriant aspect, and vigorous, woody growth, the young shoots thick, succulent, and angled in cross section, and the whole plant giving the idea of a larger and more highly developed form of vegetation. As in the case of the Asiatic sorts, there is much variety in constitution and habit, for instance, in early or late bearing properties and duration of life, some kinds coming into flower in three or four months from the seed, while others are later by many months.

being of a shrubby or even tree-like character, and remaining productive for ten years or more. All are, properly speaking, perennial, though short-lived, the only practical difference among them in this respect being that the early fruiting kinds can be sown in the spring in temperate countries, and picked before the frosts, while the later ones are for the same reason destroyed before they have had time to come to maturity. The knowledge of these facts is of the greatest importance in the selection of sorts for the description of climate in which it is proposed to grow them.

Without attempting to dogmatize as to what are, and what are not, species proper, it may be safely said that the whole group may be divided into two great sections, to wit, the smooth and the hairy-leaved kinds, or, in the language of science, *Barbadense* and *Hirsutum;* the chief of these two in commercial excellence are the Sea Island and New Orleans respectively. Under these heads are included several forms or races, permanent by seed, and so far entitled to the rank of species, with a vast number of culturable varieties of every possible quality and characteristic.

The points of difference between the two sections are but slight and few, though of a fixed and invariable nature. The Barbadensian, or black-seeded cottons, have clear, pure yellow blossoms, with a reddish-purple spot at the base of the petals, the flower itself being somewhat tubular in form and trumpet-shaped at the mouth. The capsule or boll is distinctly pitted with glandular depressions, and the whole plant is virtually glabrous from the almost total absence of hairs.

The *Hirsutæ*, or hairy cottons, on the other hand, are more or less covered with a distinct clothing of hairs. The blossoms are white, or faintly primrose coloured, in one race or sub-species obscurely spotted at the base, and in form widely expanded or patulous; the boll is smooth on the surface, and wanting the depressions peculiar to the other species. I shall call them Orleans, or white cottons. We cannot separate the two by the appearance of the seed, as the black cottons are often clothed with a tuft of short hairs or fuzz at one or both ends, and are also, but more rarely, downy all over; on the other hand, the Hirsute group are also found with seeds black or naked, often from the effects of bad cultivation, but in other instances from the natural habit of the plant.

These singular changes of character in the seeds have given rise to the belief amongst planters, that soil and cultivation have the power of converting the two kinds, mutually, one into the other; some of our best authorities have, in fact, for the same reasons, classed them together as one species, viz. *Barbadense*. Recent experiments, however, extending over many years, have led to the almost certain conclusion that no true change takes place, each section preserving its real characteristics unaltered for generation after generation.

Proceeding to the consideration of the chief sorts used in commerce at the present day, it is a remarkable circumstance that, while most of the officinal plants and fruits in general use have owed their excellence to ages of cultivation, the two most important kinds of cotton, for which indeed the rest are little better than substitutes, seem to have sprung suddenly into existence, endowed with an excellence which has never as yet been surpassed. These are the two kinds called Sea Island and New Orleans. The Sea Island, which is merely a refined and beautiful form of the large, coarse-growing, glabrous-leaved cottons of the Western world, was first cultivated in the United States towards the close of the eighteenth century by a planter of the name of Spalding, to whom it was sent by a friend from the Island of Anguilla. It is a plant of delicate constitution, not a good bearer, but fortunately early in maturing its produce. The low-lying islands off the coast of Georgia furnished the soft, maritime, and almost frostless climate fitted for its cultivation, and here it flourishes, surpassing all others in the unexampled strength, length, and beauty of its staple. It was long supposed that this favoured tract of country was alone fitted for its growth; but of late Australia and the Polynesian Islands are bidding fair to rival the old habitat. Sea Island cotton of very high quality has been grown in the Fiji group and Tahiti, and Queensland appears capable of producing this as well as the other sorts, to any extent, should its cultivation prove profitable to the colonists.

Less is known as to the origin of the white, or Orleans, cottons. The green-seeded race of these seems to have been known in Southern Italy as soon, or perhaps sooner, than in that country, where it now as it were rules the cotton world under the name of "Middling Uplands." There are two somewhat distinct breeds of the plants; the one just alluded to with green seeds and hardy constitution, the other with white, tawny, or greyish seeds (white in its best form), longer, and more silky in staple, and succeeding better in the Southern States. The last is known by the name of Louisiana, Mobile, &c., but both sorts contribute to the great mass exported under the name of Orleans or American. It is probably of Mexican origin. A large and showy form of it is occasionally cultivated, and not unfrequently sent home by travellers for its size and beauty, under the name of Cuba Vine Cotton, while another kind, bearing yellow or brown staple, was formerly grown for the purpose of making the once fashionable nankeen cloths. This has still a special market, but is not now imported into the British Islands. When the Orleans cottons have been cultivated long in the same ground without due care in procuring fresh seed, they are found to lose the woolly coating which should clothe the seeds, and become otherwise more or less permanently deteriorated. Accurate observations, however, of late years have proved that the staple does not lengthen, as some have supposed, nor does the plant when in this condition in any way depart from the Hirsute or Orleans type.

The fine Venezuela cotton belongs also to this race, for although mimicking by its naked seeds and beautiful staple the Sea Island kinds, yet it is stamped by its hairy habit, pale, self-coloured blossoms, and smooth circ... and fru...e, as a white cotton.

...me may also be observed with regard to the ages of cu... cotton, for which ...bon, which is undoubtedly a mere ... of the Orleans type, with black seeds, and of a more shrubby and perennial habit. Attention may specially be directed to this plant, as *Barbadense* has generally been translated "Bourbon" cotton. Other plants of this type are occasionally met with, but none of sufficiently important qualities to make themselves a name in the markets.

Intermediate between these and the true black cottons comes a remarkable race, best known by the name of West Indian Greenseed. They are shrubby or subarboreous late-bearing plants, possessing the hairy leaves and smooth capsules of the Orleans race, and differing only from them by a faint blotch of purple at the base of the pale yellow petals. The staple produced by these kinds is silky, strong, and good, but it has been driven of late out of the markets by the more profitable cultivation of sugar in the Islands.

The black or long-stapled cottons (*Barbadense*) are far more varied in form, of every degree of quality, and widely spread over all the warmer parts of the world. They are all more or less like the Sea Island, which I have taken as their type, but some of them possess and retain, by seed, so strong an individuality, as to have been classed by the older botanists as species. Of these the fine Peruvian cotton is one instance, where the seeds are often as much clothed or fuzzed as those of the Upland and other hirsute sorts, and the leaves, especially in the hill countries, are soft and downy, but not hairy. Another robust growing kind, with smooth leaves and very large black seeds, is much cultivated in Peru, under the name of Criollo or *Creole,* and produces the so-called "Payta," from the port whence it is shipped. But cotton-planting upon a large scale has been of late years entered into by some English settlers, who have introduced the best American kinds and cultivated them with success.

Brazilian cotton, proper, is mainly produced by the curious plant known by the name of Kidney Cotton, *Acuminatum* of Royle, *Religiosum*, *Braziliense*, and *Peruvianum* of other authors. Although considered by good authorities as a species, it has little save the singular arrangement of its seeds, which lie in a compact mass, to distinguish it from the other large forms of naked-seeded cotton. Varieties of this cotton, with fuzzed seeds and also with brown or nankeen staple, are sometimes obtained from Parahyba. Various other large black seeds, however, of the Criollo type are much cultivated in the Brazils, which add to the mass of staple imported under the name of Brazilian. These last are doubtless forms of the *Vitifolium* of the old botanists.

A good deal of short staple (Uplands and Orleans), however, has been cultivated from time to time in these countries, and since the opening of the new Saô Paulo Railway, by the exertions of Mr. Aubertin, late superintendent of the works, in connection with the Cotton Supply Association, which furnished the seed for the first experiments, a new cotton field has been opened up, where Orleans is successfully grown, and now holds a place in the market under the name of "Santos" cotton.

The late Viceroy of Egypt, the well-known Mehemet *Ali*, introduced in 1821 a hardy but coarser form of

Sea Island cotton into his dominions, which, though inferior to it in quality, has yet sufficient length, strength, and general properties to make it an important and most useful staple. It is grown under irrigation from the waters of the Nile, and is exported generally more or less mixed with pure Sea Island for the purpose of bringing up the quality. It ranks as a long cotton, and always finds a ready sale.

Cotton has occasionally been sent to England from Africa grown from the so-called native seed, but it has generally proved to be inferior forms of both the black and white seed kinds, and not a desirable staple. Good cotton, however, has lately been grown from American seed by settlers from England both in Natal and in other parts of the continent; and there can be little doubt, judging from the results already obtained, that Africa will one day become a large and important cotton field. A remarkable species, brought by Sir Samuel Baker from Central Africa, said to bear red blossoms—quite a new feature in the occidental races—may be seen in the collection at Kew.

With respect to published works upon the botanical part of the subject, the most reliable source of general information is Dr. Royle's exhaustive treatise, entitled 'The Culture of Cotton in India,' where references to the various authorities and herbaria are given. Since his time no other important treatise has appeared. Professor Parlatore describes the cotton which he has seen cultivated in Italy in a handsomely illustrated folio with coloured plates and letterpress, but no work of a monographic character upon the genus has yet been executed to clear up the confusion existing upon this little understood and difficult subject. The earlier botanists seem to have been acquainted with scarcely any but cultivated specimens, their habitats as given are frequently inaccurate, much copying by one writer from another exists, and species have been produced by combining the characteristics of several sorts, so that altogether the old botany is of but little interest and value except as a matter of curiosity. The plants must be studied in their living state, in their native habitats, in the cotton field where cultivated, and in our botanical glasshouses at home, by anyone who shall purpose to work out a really thorough investigation of the subject. This has been done to a large extent by Colonel Trevor Clarke, to whom we are indebted for much of our present information. He has made the plant his special study, and deserves great credit for his zealous efforts to promote its improvement by hybridization. A rare collection of about a hundred living plants of different varieties, produced under his own superintendence, was shown at the London International Exhibition of 1872, and it is to be hoped that ere long he may be prevailed upon to undertake the important task of supplying the much-needed treatise on the different branches of the Gossypium family, which shall remove the confusion in which its genealogy is still involved.

Cotton Supply.

Amongst British manufacturing industries, there is none perhaps which has shown a more marvellous development than the cotton trade. So wonderful and rapid has been its expansion, that it has not been easy to provide adequate and steady supplies of the raw material required, and much anxiety has from time to time been occasioned, whenever these have been threatened with diminution or interruption. The possibility of a cotton famine has been sternly demonstrated, and thousands were for a season deprived of employment and the means of subsistence. The achievements of Watt and Arkwright, of Kay and Crompton, of Hargreaves and Cartwright, by reducing the cost of manufacturing processes, and contributing to the production of cheaper and more perfect fabrics as a necessary consequence, speedily led to their more extensive use. The astonishing progress which followed the introduction of the "Spinning Jenny" by Richard Hargreaves in 1767, and the mechanical inventions which afterwards rapidly came into operation, made it necessary not only to seek new markets for our manufactures, but also more abundant supplies of the raw material required to produce them. The average annual import of raw cotton from 1771 to 1775 was about 12,000 bales of 400 lb. each, but from 1796 to 1800 it had increased to nearly 94,000 bales of the same weight. Until the commencement of the present century, America contributed but a very insignificant portion of the cotton consumed. It is related that "in 1784 an American ship which had imported eight bags of cotton into Liverpool was seized, on the plea that so much cotton could not be the produce of the United States." By the year 1800 the American imports were nearly 45,000 bales of 400 lb. each. At the close of the war in 1815, when the prospects of foreign trade began to brighten, and lead to an increased demand for our manufactures, the production of cotton in the United States received a fresh impetus, and the subsequent progress became continuous and rapid. The lead then taken by the Southern States was steadily maintained for nearly half a century, all competitors were soon distanced, and a virtual monopoly was eventually established. Increased production brought with it lower prices, and cotton worth 22*d.* per lb. two years before, fell in 1819 to 12*d.*, and subsequently in 1848 to $4\frac{1}{4}$*d.* per lb. Although during the ten years immediately preceding the American civil war the growth of cotton in India had been largely increased, still the Southern States continued to maintain the ascendency, until in 1860 about 85 per cent. of the quantity of cotton consumed by our manufacturers was derived from this one source. Its cessation, occasioned by the attempt of the Southern States to establish their independence, brought about the cotton famine with all its losses and sufferings, and gave a fresh stimulus to the exertions of the Cotton Supply Association, which had been previously established to promote the growth of cotton in other countries, especially in those under the dominion of the *British* Crown. By its instrumentality the world was

Imports of Raw Cotton into the United Kingdom, in Bales, during the Ten Years previous to the American War, viz. from 1850 to 1859, inclusive.

	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.
America	1,182,970	1,397,112	1,788,685	1,532,063	1,666,479	1,623,478	1,758,295	1,481,715	1,863,147	2,086,124
India	309,168	326,474	212,361	485,527	308,293	396,014	463,932	680,466	360,980	509,695
Brazil	171,359	108,670	144,214	132,443	107,393	134,762	122,411	168,340	106,127	124,930
Egypt	79,376	63,833	189,865	105,398	81,085	115,018	112,911	75,598	105,603	101,427
Smyrna	157	3,630	20	..	..	..	..	..	500	1,700
Peru	..	47	90	2,879	1,637	1,441	4,300	3,788	1,812	1,496
West Indies, &c.	5,107	4,799	12,043	5,960	7,710	7,505	7,020	7,679	4,460	3,528
Total ..	1,748,137	1,904,565	2,357,278	2,264,270	2,172,597	2,278,218	2,468,869	2,417,586	2,442,629	2,828,900
Total in bales of 400 lb. each.	1,714,000	1,900,250	2,313,000	2,255,750	2,216,500	2,252,750	2,552,500	2,440,250	2,563,750	2,977,000

Imports of Raw Cotton into the United Kingdom, in Bales, for the Ten Years ending with 1869.

	1860.	1861.	1862.	1863.	1864.	1865.	1866.	1867.	1868.	1869.
America	2,580,980	1,841,643	72,369	132,028	197,776	460,606	1,162,745	1,225,686	1,269,060	1,039,641
dia	562,738	986,290	1,071,768	1,229,984	1,399,514	1,266,513	1,847,759	1,508,754	1,451,979	1,496,426
zil	103,084	99,224	133,807	137,142	212,192	340,261	407,646	437,208	636,897	514,200
pt	110,009	97,759	135,420	205,788	257,102	333,575	167,451	181,173	188,689	185,670
na ..	100	957	14,851	42,282	61,793	79,803	32,770	16,995	12,758	40,957
	2,515	2,667	5,400	15,521	27,059	71,794	49,081	64,423	58,881	62,228
	..	..	..	160,807	399,074	141,610	18,844	1,942	93	..
	,259	7,188	11,436	8,610	32,586	61,159	62,745	64,593	41,770	43,042
	685	3,035,728	1,445,051	1,932,152	2,587,096	2,755,321	3,749,041	3,500,774	3,660,127	3,382,164
	00	3,153,500	1,332,750	1,729,500	2,240,250	2,416,000	3,384,500	3,156,340	3,320,210	3,053,067

QUANTITY OF RAW COTTON, IN BALES, TAKEN FOR CONSUMPTION IN THE UNITED KINGDOM DURING THE TEN YEARS BETWEEN 1850 AND 1859, TOGETHER WITH THE AVERAGE PER WEEK.

	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.
America	1,079,884	1,272,062	1,507,765	1,407,963	1,526,539	1,577,948	1,686,955	1,352,735	1,638,627	1,906,766
India	176,020	194,354	160,461	196,587	207,723	276,834	281,452	362,076	322,570	177,465
Brazil and West Indies	178,412	121,276	134,327	130,412	109,850	123,528	161,881	162,817	123,819	111,392
Egypt	80,184	74,893	109,005	119,618	105,215	120,988	133,611	83,918	89,543	98,687
Total ..	1,514,500	1,662,585	1,911,558	1,854,610	1,949,327	2,099,298	2,263,899	1,960,586	2,174,559	2,294,310
Average consumption per week ..	29,125	31,973	36,760	35,666	37,487	40,371	43,536	37,703	41,811	44,167

QUANTITY OF RAW COTTON, IN BALES, TAKEN FOR CONSUMPTION IN THE UNITED KINGDOM DURING THE TEN YEARS BETWEEN 1860 AND 1869, TOGETHER WITH THE AVERAGE PER WEEK.

	1860.	1861.	1862.	1863.	1864.	1865.	1866.	1867.	1868.	1869.
America	2,241,590	1,690,743	198,549	108,588	158,776	279,916	931,335	1,061,526	1,112,270	911,741
India	176,068	355,300	710,228	750,404	746,694	876,053	922,289	854,824	800,449	958,936
Brazil	113,374	82,374	102,797	103,212	155,742	218,971	290,186	325,198	597,847	442,290
Egypt	95,829	111,499	109,800	197,028	227,662	297,365	161,891	156,423	183,639	182,390
China	..	..	..	92,387	212,074	173,600	10,454	1,322	833	..
West Indies, &c...	6,384	13,802	24,107	51,843	105,488	189,176	120,946	115,511	103,899	132,527
Total ..	2,633,245	2,253,718	1,145,481	1,303,462	1,606,436	2,035,081	2,437,101	2,514,804	2,798,937	2,627,884
Average consumption per week ..	50,639	43,340	22,029	25,067	30,893	39,136	46,867	48,362	53,825	50,536

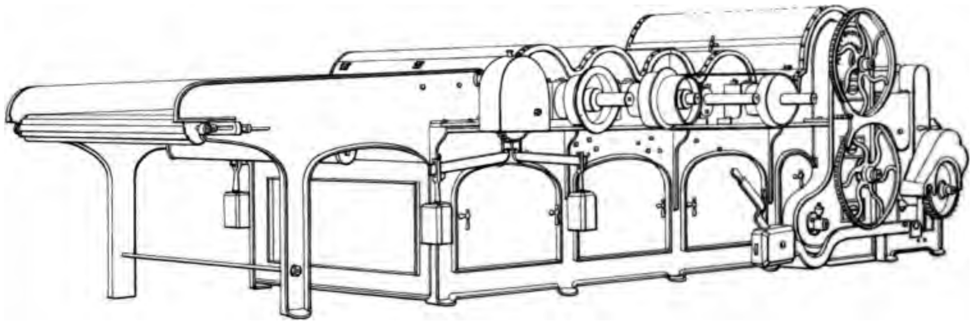
ransacked for cotton, new sources of supply were opened, and others, which had previously grown but little of the much-needed staple, became important contributories. The imports from India increased threefold, and from Egypt, Brazil, Turkey, the West Indies, and other quarters in a similar proportion. The annexed tables, exhibiting the imports and consumption during the periods specified before and since the American civil war, as compared with the early part of the present century, afford a striking illustration of the rapid development of the cotton trade.

Cotton Ginning

Is the process by which the seed is separated from the fibre or wool. The lobes in every ball of cotton contain seeds resembling unground coffee, which, when removed, leave only about one-third of the quantity gathered from the tree in clean cotton, that is to say, two-thirds of the cotton grown and picked consist of seed, and one-third of the raw material fit to be used by the manufacturer. The process of separating the seed is performed in various ways, and is still susceptible of further improvement. The most primitive machine for the purpose still in use is the Indian Churka, employed extensively by the Hindoos, and found in Italy under the name of Manganello. It consists of two rollers made of hard wood fixed in a rude frame, through which the cotton is drawn and the seeds forced out in the process. The operation is tedious and laborious, and the quantity of cotton that can thus be cleaned by any one machine exceedingly small. The fibre, however, is not injured, except in some slight degree by the curl which it receives in passing through the churka. Various attempts have repeatedly been made by means of iron or steel rollers, grooved longitudinally to increase the out-turn, but with no satisfactory results; and the insufficiency of the churka, whether worked by hand or power, to clean any large quantity of cotton, has been fully and clearly demonstrated.

In 1792 Eli Whitney, an American, initiated a new system of ginning by the invention of the saw-gin, which consists of a series of saws revolving between the interstices of an iron bed upon which the cotton is placed, the fibre being drawn through the slits in the bed, leaving the seeds behind. This invention realized the object sought by cleaning the cotton with greater rapidity and at less cost than previously, but in the process the quality was considerably deteriorated by being cut and "nepped." Numerous attempts have since been made to remedy the defects of the machine, but though there has been considerable improvement since the days of Whitney, and the saw-gin is still in general use in the Southern States and elsewhere, there is still much ground for the complaint that the fibre is injured, and the value of the cotton depreciated by this mode of ginning. This is especially found to be the case in all long-stapled cottons, such as Sea Island, Egyptian, and Brazilian. The special recommendation of the saw-gin is the large quantity of work which can be done by it, and if such improvements could be effected as would prevent injury to the staple, nothing better could be desired. There is still hope that this may eventually be done, and a recent American invention known as the "needle saw," consisting of steel wire set in block tin, leaving the bottom of the teeth round and smooth, which, it is said, will prevent the fibre from being cut and nepped, may possibly contribute towards the realization of this hope.

The great competitor of the saw-gin is the Macarthy gin, also an American invention, a machine of simple construction, intended to be capable of cleaning large quantities of cotton expeditiously without occasioning any injury to the staple. In this machine the cotton is drawn by a leather roller between a metal plate called the "doctor," fixed tangential to the roller, and a blade called the beater, moving up and down in a plane immediately behind and parallel to the fixed plate. Whilst the cotton is drawn through by the roller, the seeds are forced out by the action of the movable blade. Since its introduction numerous modifications of the Macarthy gin have been made, and in some cases the movable blade or knife is made to work horizontally instead of vertically. Attempts, more or less successful, have from time to time been made to improve the original Macarthy gin, so as to increase its capabilities of cleaning large quantities of cotton quickly. This is the aim of the double action Macarthy, with a double knife arrangement, or two movable blades or "beaters." The "Knife-roller" gin, the "Lock-jaw" gin, and others have been introduced as competitors to the saw-gin, which, however, continues still to be generally used in the cotton-growing territories of the United States, though there is much room for the further exertions of inventors to improve the machinery required for the operation of ginning. Both cotton spinners and cotton growers are interested in the production of the most perfect cotton-cleaning machinery, the former well knowing how much their work is facilitated or hindered by the way in which the raw material used in their mills is prepared and sent to market. Nor are they alone concerned, for the cultivators of cotton are greatly benefited by such improvements as tend to economize labour and to enhance the value of their crops. Often has the deterioration in the quality of cotton occasioned by bad ginning been so great, as to cause serious loss to the producer, especially in the longer staples. Frequently have 2*d.* and even 4*d.* per lb. been thus sacrificed, and cotton has been bought at 10*d.* per lb. which, had it been properly cleaned, would have been worth as much as 1*s.* 6*d.* The rivalry so long maintained between the saw-gin and the roller-gin has had the effect of stimulating the zealous advocates of each to make strenuous exertions to promote improvements, and whilst both machines have thus been rendered more efficient than they once were, there is still ample encouragement for further efforts, which in proportion to their success cannot fail to be appreciated and rewarded.



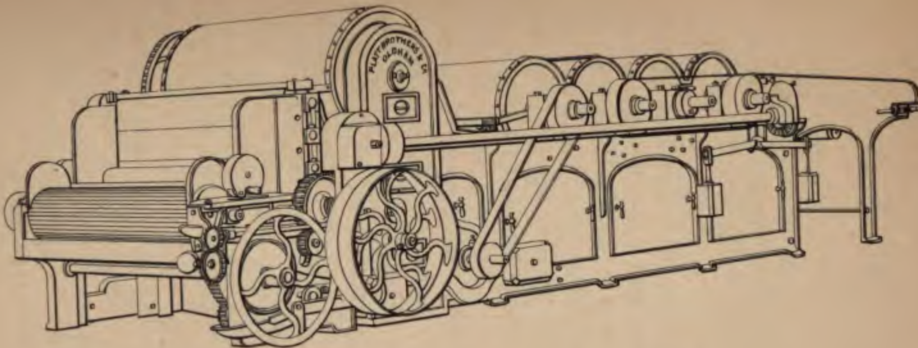
4 CYLINDER COTTON OPENER

Cotton Spinning.

Cotton Spinning comprises the various processes by which the raw material is converted into yarn to be afterwards woven into cloth. Though of great antiquity, it was, until about a century ago, performed solely by hand, by the simple and rude appliances which are still to be found in Eastern countries where progress and civilization have but little advanced, but which have been entirely superseded in these Western regions by the marvellous inventions of modern times. The ancient and venerable occupations of former days, when the skilful "did spin with their hands," and the wise made diligent use of the distaff, have disappeared from amongst us. In our familiarity with the inventions which have been so long in operation, we are apt to overlook the extraordinary character and importance of the revolution which has thus been effected.

An abortive attempt to introduce machinery was made in 1738 by John Wyatt, of Birmingham, but it was not till 1767, on the introduction of the "spinning jenny" by Richard Hargreaves, that any real progress was made. Since then, the achievements of Watt and Arkwright, of Kay and Crompton, of Hargreaves and Cartwright, and other less known inventors have carried the process of cotton spinning to an astonishing degree of perfection.

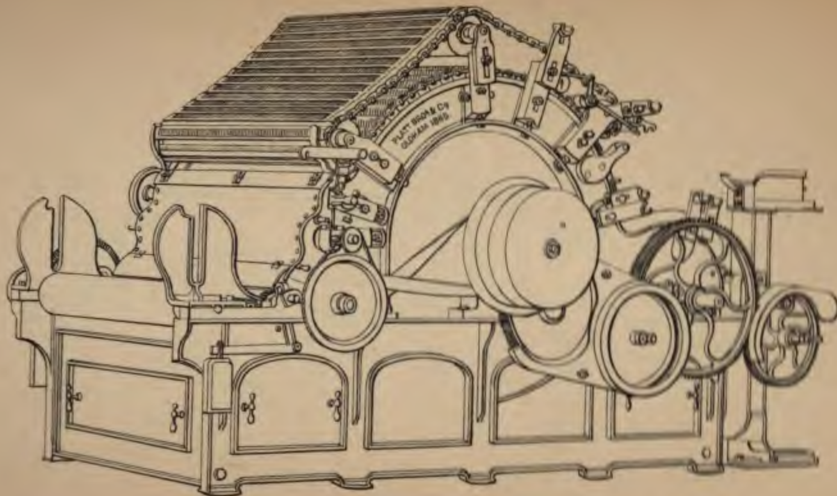
The raw cotton, which is received in bales, has first of all to be opened and thoroughly mixed, in order to lessen the irregularity which might arise from a difference of quality. This process is performed by spreading out the contents of the various bales in layers one above another, and to ensure that a portion of each layer shall be in the opening machine, vertical slices are taken from the stack of cotton or "mixing" and placed in position to feed the "opener." This machine is used to break up any hard lumps that there may be, and to remove any dirt which the cotton may contain. Different machines are employed for the purpose, bearing various designations, such as "Oldham Willow Opener," "Porcupine Opener," "Lord's Patent Opener," "Crighton's Opener," &c. The action of the opener carries the cotton, first placed on a feeder, forward by a combination of rollers, and before delivery by these rollers, it is struck several times by revolving blades or teeth, which serve to loosen the fibres, at the same time disengaging the dirt, and allowing it to fall through grids, which allow the impurities to pass but retain the fibre. The draught caused by a fan carries the cotton forward to cages, whence it is delivered to the lap machine. The scutching and lapping machine is designed to effect a further separation of the fibres of the cotton, and to remove such refuse material as may still remain. The cotton is left by the opener in a fleecy state, but by means of the scutcher, to which a lap machine is attached, it is formed into a roll or "lap," preparatory to the operation of carding. Scutching is necessary to the formation of a level lap, but if long-stapled cottons are blown or scutched too much, they are liable to become "stringy," and therefore special care



FRONT VIEW OF COTTON OPENER

in feeding is necessary. The scutcher, which was invented and brought into operation early in the present century, is now made with two, three, and, in some cases, even with six beaters, and is found to answer so satisfactorily, that machinists differ but little in its construction. As Indian or Surat cotton, from being too tightly pressed, sticks together in cakes when opened, as if glued, and can be torn asunder with difficulty, steaming has sometimes been resorted to before scutching, but this expedient is now seldom employed. The scutching process ranks in importance next to that of carding, and must be regulated both by the quality of the cotton used and the numbers of the yarn intended to be spun.

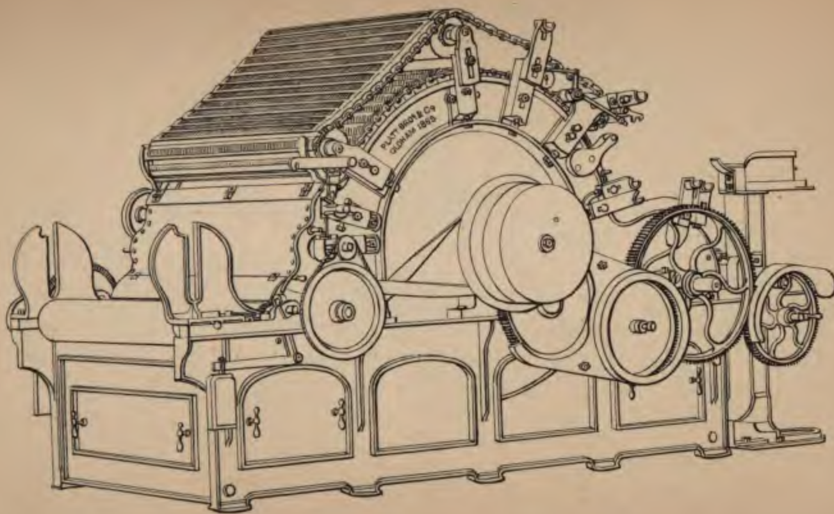
The most important operation in cotton spinning is that of carding, which comes next in order. After the raw material has passed through the opening and scutching machines, the fibres are found matted together or lying in different directions, and they must first be stretched out and placed parallel to each other, before they can be spun into a thread. From their tendency to curl, repeated brushing or combing is necessary, not only to place the fibres straight, but to remove such as are short in length, as well as the neps and any other remaining impurities, which might tend to injure the yarn. If the invention of the carding engine cannot be ascribed to Arkwright, its improvement must unquestionably be attributed to him. The principle which he established remains essentially the same, and is in operation whatever kind of carding engine may be adopted. A



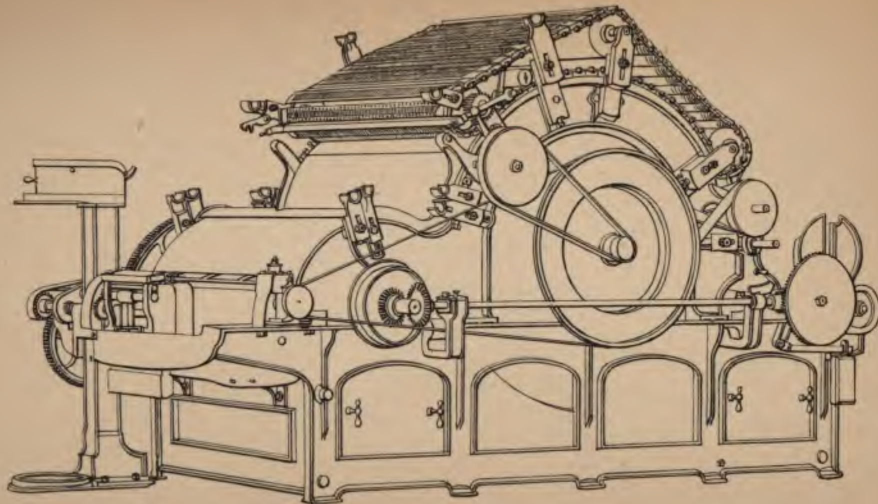
CARDING ENGINE

large cylinder is made to revolve in an iron frame, partly surrounded by rollers and clearers, technically termed "flats," which are clothed with cards covered with fine wire points set as closely to each other as possible without actually touching, the wires of the main cylinder and of every alternate roller being set in opposite directions. The lap from the blowing machine is turned into the carding engine by a pair of fluted feed rollers, and is broken up, a cylinder of about 8 inches diameter (called the breaker) revolving quickly close to the feed rollers, off which the cotton is taken by the main cylinder and passed on in this way by the rollers and clearers, until it reaches the doffer or doffing cylinder. The fleece of cotton is taken from the doffer by the comb and is then called the sliver; and this, passing through a trumpet-mouthed aperture with the fibres laid out in order, is coiled into the doffing tins or cans. It is of importance that the cylinders be perfectly true and well balanced, and that the wire cards be frequently and accurately ground, so as to keep sharp points. A most ingenious and successful piece of mechanism, called a combing machine, first invented by a Frenchman named Heilsmann, about thirty years ago, but greatly improved since its introduction into England, is now in extensive use amongst the fine spinners. For medium counts of fine quality it is also sometimes used after the breaker carding engine, and instead of the finisher card, where a superior quality of work is required.

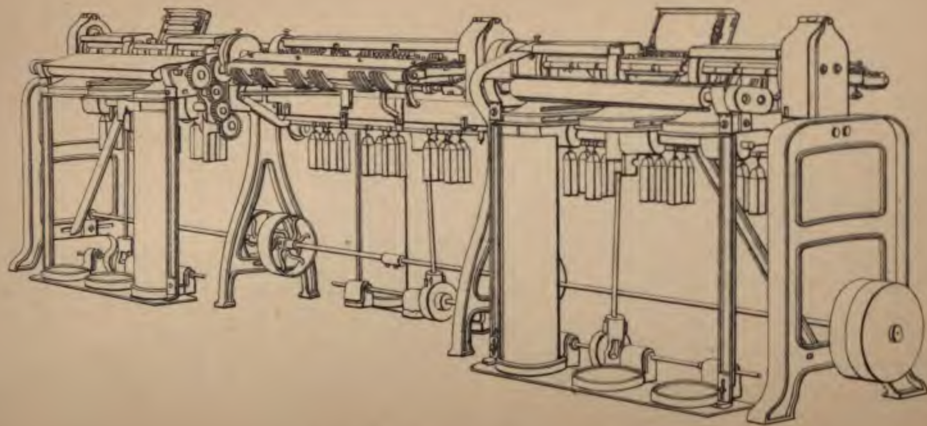
The processes of elongation or attenuation are carried on through the drawing, slubbing, intermediate,



CARDING ENGINE



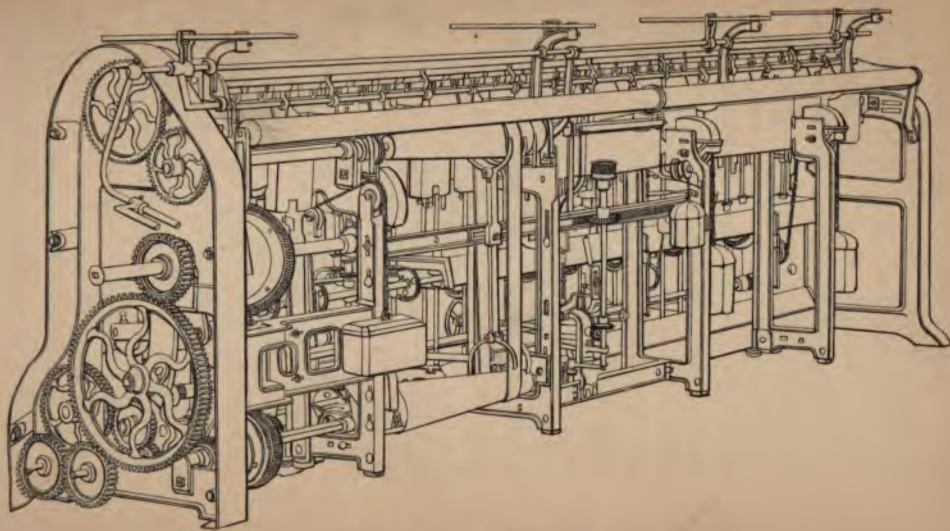
CARDING ENGINE, WITH FLATS



DRAWING FRAME

and finishing roving frames. The drawing frame comes into operation after carding, and is a machine for straightening and laying parallel the fibres of cotton. In it the process of doubling is commenced, and the cotton is drawn out, as the name indicates. This is effected by doubling and drawing out the slivers repeatedly through successive pairs of rollers with which the drawing frame is furnished, the lower or bottom rows being fluted, and the upper or top rollers covered with flannel or cloth and leather neatly cemented together, and weighted down to the under rollers, so as to be driven by friction from the lines of under rollers. There are generally four rows of rollers in each drawing box, and three drawing boxes to each drawing frame. Six ends or slivers are, as a rule, put up to each box and drawn down into one by each line of rollers going at an accelerated speed, the front roller revolving about six times faster than the back roller. The first doubling being 6 into 1, the next will be 36, and the third 216. Fine spinners will sometimes have four heads of drawings and double 8 ends into 1 at the first head and 6 into 1 afterwards, which makes the total number of doublings in the drawing frame 1728; but coarse spinners will sometimes only have two heads of drawings with 36 doublings. The drawing frame, on account of its great speed, requires to be "scoured through" or thoroughly cleaned more frequently than any other machine in a cotton factory.

The operation which follows the drawing is that of slubbing, where the sliver has a certain amount of twist imparted to it, and is wound on a bobbin. The slubbing frame is a machine which first draws out the end or sliver from the last head of the drawing frame, by means of three pairs of rollers; and this is twisted as it emerges from the front line of rollers by means of vertical spindles and flyers, which at the same time wind the ends upon bobbins in successive layers. As the bobbins fill and increase in diameter, they are gradually slowered at each layer by a very ingenious piece of mechanism, known as "the sun and planet motion," consisting of a large wheel within which two other wheels are made to work, the interior one having a regular motion, and the sun-wheel being driven from a pair of cone drums with a rate of speed constantly decreasing. Thus the slubbing frame answers three purposes: it draws out the cotton, twists it, and winds it upon a bobbin, the first being done by the rollers, the second by the spindles, and the third by the flyers and pressers. The intermediate frame follows the slubbing frame, which it resembles in construction, though it has a larger number of spindles and smaller-sized bobbins. Instead of having cans put up at the back, it has what are termed "creels," in which the slubbing bobbins are put so as to be drawn off through the rollers of the frame and doubled two into one. It is called the intermediate frame, because it comes between the slubbing and roving frames, whenever the numbers to be spun exceed 20's. Spinners of low numbers or counts seldom use this frame, but set the slubbing-frame bobbins into the "creels" of the roving frame. Though attempts have been made to dispense



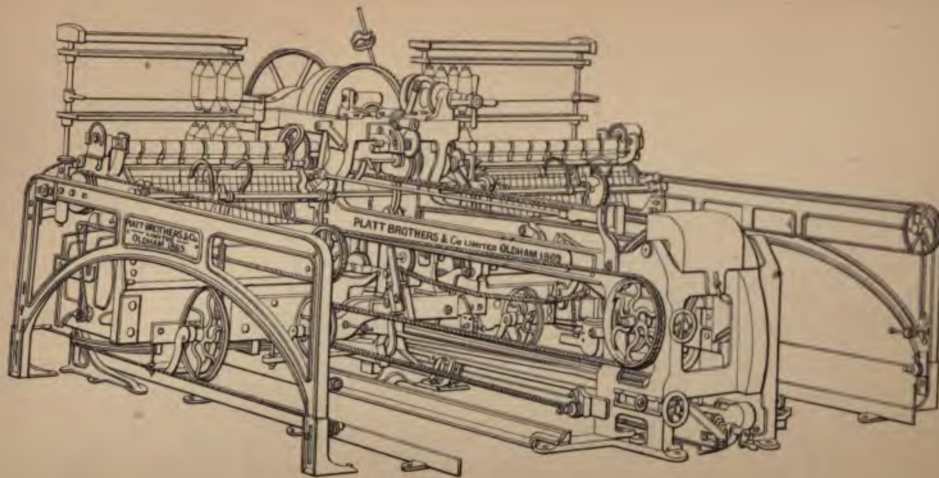
SLUBBING FRAME

with its use in spinning numbers up to 30's or more, it has not been found expedient to do so, and it is still retained in such cases by the best class of spinners.

The roving frame resembles in principle the slubbing and intermediate, and is the last required before the operations of spinning, strictly so called, commence. It has a greater number of spindles than either of the two preceding frames, seldom less than a hundred, and sometimes over two hundred, these spindles being set closer together, and the bobbins shorter and finer than in the intermediate frame. The degree of elongation completed by the roving frame is technically described by the number of hanks roving, and the thread of a certain thickness is called so many hanks roving. In the spinning of fine numbers or counts, the "Jack frame" is used for a second roving, making a 30 or 40 hank roving from the bobbins of the first roving frame; that is to say, these fine roving frames occasionally make rovings as fine as 30 or 40 hanks to the pound.

In the spinning operations proper there are two kinds of frames or machines in general use, viz. throstles and mules. The contemporaneous inventions of Hargreaves and Arkwright, though at first encountering violent opposition, contributed, in conjunction with the invention of the mule a few years later by Samuel Crompton, to bring about speedy and important changes in the process of cotton spinning, and have since given to this branch of our national industry a development which has been the wonder and admiration of the world. This remarkable progress is, of course, also to be largely ascribed to the invention of the steam engine.

The throstle, an extension and modification of the original spinning frame, first called the "water frame," is employed in the spinning of yarn for warps, and the yarn so spun is still known by the name of "water twist." Whether the designation "throstle" is derived from the humming or whistling noise made by the machine whilst at work, as some persons conjecture, or from some other cause, has not been authoritatively settled. Since its invention by Arkwright, numberless attempts have been made to effect improvements, but it still remains in principle the same, and the common throstle is distinguished amongst spinning machines for its simplicity. The throstle-frame consists of a creel containing the bobbins from the roving frame in the centre, having on each side a set of three rows of rollers through which the roving is passed or drawn out to the required thickness. The bottom rollers are iron fluted, and the top ones are covered with leather, the speed being so adjusted that the front rollers move faster than those behind them. Below the rollers on each side is a row of spindles fitted with bobbins, and on the top of the spindles flyers are screwed, round which the thread passes and is twisted by the spindles revolving at a great velocity, whilst it is lapped upon the bobbin by the flyers. The yarn spun upon the throstle has its fibre closer twisted than that spun upon the mule, and is more esteemed for certain purposes, especial[illegible] thread, than the latter. Throstle yarn [illegible] even than mule yarn, and


PLATT BROTHERS & Co LIMITED OLDHAM 1869
PLATT BROTHERS & Co. LIMITED OLDHAM 1869

MULE

better adapted for warps; but the range of throstles is limited, and the counts seldom exceed 30's. The mule, on the other hand, will spin both twist and weft, and as high as No. 80's, while finer numbers can be spun by hand-mules. Mule yarn is softer and more woolly in texture than throstle yarn, which arises from the vibration of the thread as the carriage is drawn out from the rollers. Throstle yarn always commands a better price than mule yarn, but it also costs more in machinery and power to produce it.

The ring spinning frame, of which there are several varieties, is chiefly used in America.

The mule, or mule jenny, the invention of Samuel Crompton, differs from the throstle in having the spindles placed in a carriage moving backwards and forwards. The twist is put in as the carriage recedes or is drawn out, and the winding of the yarn upon the cop is performed by a separate motion as the mule or carriage moves up, the principle of drawing being the same in both throstle and mule. Instead of bobbins the yarn is wound on spindles, in the form of a cylindrical cop. Whilst throstle twist is used only for the warp, mule twist can be used either for the warp or weft, to fill up the warp in weaving, and finer counts can be spun on the mule than is possible on the throstle, the finest and most delicate yarns being spun upon the mule. The cost of hand-mule spinning having been found to be so much greater than that of any of the other processes in the production of yarn, stimulated the ingenuity of mechanics to discover some means of diminishing that item of expense, and about the year 1832 the self-acting mule was brought into prominent notice by the successful efforts of Mr. Richard Roberts, a man of a versatile genius, though of humble origin. His invention of the "quadrant motion" overcame the difficulty which had baffled those who had preceded him, in the attempt to discover the best mode of winding the yarn upon the bare spindles to produce a set of cops, till the cone is formed. Various improvements have since been made in the self-acting mule, but Roberts's "quadrant winding motion" remains unsurpassed, and has proved of inestimable value to the cotton spinner, though the inventor himself died in poverty and unrewarded.

Yarn when spun, besides being woven into cloth, is also doubled and used for a variety of purposes, as thread, and in the manufacture of hosiery, fancy goods, &c. Single yarns are frequently doubled in many folds in what are called doubling mills; but this is an operation distinct from cotton spinning.

Some idea may be formed of the extent of this branch of British industry from the following statement of the exports of yarns and piece goods during the past three years, taken from the Board of Trade returns, viz.: Exports of yarns in thousands of pounds:

1874.		1873.		1872.
220,599	..	214,779	..	212,328

Piece goods in millions of yards:

1874.		1873.		1872.
3,603·3	..	3,483·7	..	3,538·0

Though cotton spinning is chiefly carried on in

Lancashire, it has extended to other districts in the three kingdoms, and from its vast proportions it has become of Imperial importance, and its prosperity or depression is felt far and wide. It has in its development afforded full scope to inventive genius, which has achieved in connection with it some of its proudest triumphs. It has to a remarkable extent been the means of raising men from poverty to wealth, and from obscurity to renown, whilst it can exhibit no insignificant roll of illustrious characters who by their originality, shrewdness, and talents have rendered good service to their country as patriots, legislators, and men of science. Happily, too, the raw material required in this great branch of British industry has ceased to be the product of forced labour, and the wail of slavery no longer mingles with the whirl of the spindle. Future generations, in looking back upon the sufferings of the cotton famine, will have cause to rejoice that since that time our manufacturers have ceased to be indebted to slave labour, and that a system so revolting to humanity has for ever been swept away.

SILK.

By B. F. Cobb, Secretary to the Silk Supply Association.

The produce of the silkworm, principally *Bombyx mori*, is the strongest, most beautiful, and most tenacious of all fibres. Its use dates back to periods of remote antiquity, for, if we may believe the Chinese historians, the art of reeling and working silk was known so far as the time of Foh-hi, which would be a century before the date usually assigned to the Biblical Deluge; and it is almost certain that 2600 years before the Christian era the Empress See-ling-chi, wife of the celebrated Huang-ti, not only superintended the rearing of the worm, but also the manufacture of the silk produced. She has in China the credit of having invented the loom, for which she holds there the position of a tutelary genius, with special altars of her own.

The present province of Shang-tung, the country of Confucius, is said to have been the district where the cultivation of silk first flourished, and from whence it spread to the Corea, and was imported to Japan about six or seven centuries before the Christian era.

In spite of every precaution, the art appears to have extended beyond the empire both west as well as east, *until in* A.D. 400 it became domiciled in Northern India.

It is said that a Chinese princess carried the seed of the mulberry and eggs of the worm across the border in the lining of her head-dress, as she went to join her betrothed husband.

From the records of the Hon. East India Company, we find that in A.D. 420 silk was produced in Khotan, from whence we may assume that it passed to Bokhara, Khiva, Samarcand, &c., &c.

In the sixth century, both the rearing and manufacturing were established in Persia, and spread, as far as the jealousy of the Persians would permit, along the south shore of the Caspian Sea. In the sixth century the silkworm was introduced into Europe direct from China by order of the Emperor Justinian. Gibbon relates how two Persian monks, who had been long resident in China, were encouraged by the emperor to return, and how they "again entered China, deceived a jealous people by concealing the eggs of the silkworm in a hollow cane, and returned in triumph with the spoils of the East."

The industry took root in Greece, at Corinth, Thebes, and Argos, but does not seem to have spread. The Moors also introduced it into Spain, although whether they derived the art from Persia or Greece is not known.

According to Gibbon, it was taken from Corinth to Sicily by the Normans; for he says, "This emigration of trade distinguishes the victory of Roger from the fruitless hostilities of the age." This would be about 1147 A.D.

Internal revolutions and domestic troubles, however, caused the cultivation to migrate to Northern Italy, where the worm seems to have found a most congenial habitat. It was not until the sixteenth century that the industry was fairly introduced into France by Francis I., who, obtaining seed from Milan, commenced the rearing in Lyons and the valley of the Rhone, where it still flourishes.

The manufacture of silk in England dates from 1585, when the sack of Antwerp by the Spaniards drove many Flemish artizans to England. This industry received a further impulse a century later from the revocation of the Edict of Nantes, when a large body of French weavers emigrated and settled in Spitalfields. The industry has always been fostered by Government, although it is doubtful if it would not have been much more vigorous and successful if left to itself. Spitalfields and distress seem to have been a good deal associated, notwithstanding this fostering care of different governments.

One of the methods adopted to improve the condition of the weavers was the encouragement to planters in our American possessions, by offering bounties on raw silk imported from thence, during the twenty-one years succeeding 1769. For the first seven years 25*l.* was to be paid for every 100*l.* value of raw silk; in the next seven, 20*l.* for every 100*l.* value; and in the last seven, 15*l.* for every 100*l.*

This was not the only attempt made to promote the breeding of silkworms in America. The Governor of South Carolina, as early as 1765, offered a premium of five hundred dollars to the first who should produce ten pounds of silk grown in the "province," as it was then termed; and many persons tried to gain it, among whom was a Frenchman named St. Pierre, who brought to this country a sample of silk grown in that state, which was pronounced "superior to any imported from Italy." Curiously enough, while a bounty was offered to promote the cultivation of the raw material, a duty of three shillings per pound was levied on it when imported into this country.

At this time, the illustrious Franklin, then in England, suggested to the recently instituted "American Philosophical Society," of which he had been elected the first President, the establishment of a filature. That learned body took the matter up warmly, a filature was erected in Philadelphia, and the cultivation of silk encouraged in Pennsylvania, apparently with much success; for we learn from 'Hasard's Register of Pennsylvania,' that from 25th of June to the 15th of August, 1771, 2300 lb. of cocoons were brought to the filature. The war of Independence put a stop to silk cultivation. At present California is the leading state for silk cultivation. The 'Alta California' informs its readers that "the Californian Silk Culture Company, near Sacramento, is exceedingly flourishing, has raised 3,000,000 worms, and has for sale some 4000 ounces of eggs, of the well-known French variety; the eggs are worth in the neighbourhood four dollars per ounce, and the raw silk ten dollars."

The rearing of the worm in England has been tried on several occasions, the most important of which was in 1825 by the British, Irish, and Colonial Silk Company, with a capital of one million sterling. It does not appear to have prospered, although smaller attempts by private individuals, generally amateurs, have succeeded better. At present the cultivation of silk is deservedly attracting much attention in the colonies, and we find New South Wales, Victoria, Queensland, New Zealand, and South Africa, all sending specimens to the Exhibition of 1873, and many of them very favourably reported upon. Some of the East Indian and Pacific Islands have made also successful but spasmodic attempts.

The value of the cocoons grown in the whole world in 1870 was said to be as follows: France, 4,334,000*l.*; Italy, 11,260,000*l.*; Spain, and other European countries, 984,000*l.*; giving a total for Europe of 16,588,000*l.*; China, 17,000,000*l.*; India, 4,800,000*l.*; Japan, 3,200,000*l.*; Persia, 920,000*l.*; other Asiatic States, 2,192,000*l.*; giving a total for Asia of 28,112,000*l.*; Africa, 68,000*l.*; America, 20,000*l.*; making a general total of 44,788,000*l.*

Silkworms may be generally divided into two descriptions or classes: the "*Bombyx mori*," or mulberry-feeding worm, from the cocoons of which is reeled the ordinary "raw silk" of France, Italy, India, China, and Japan; and the Tussah worm, which feeds upon certain descriptions of oak, ailanthus, castor-oil plant, &c., &c., the produce of which was little heard of in this country until recently, and, but for the outbreak of the silkworm disease in Europe, would probably have remained in India and China, although it had been *utilized* in both these countries for many centuries.

Another result of the ravages of this disease, which made its appearance to an alarming extent in 1854, was the trade in Japanese eggs (graine), with the view of introducing a healthy stock to replace the native races fast dying out; and it is stated that in 1865 nearly three millions of cards, or as many ounces of seed, were exported from Japan to Europe.

	oz.
In 1866 the quantity was	950,000
1867 " "	850,000
1868 " "	2,300,000
1869 " "	1,390 000
1870 " "	1,365,000

The export of silkworms' eggs in 1869 was, to France, 3776 cases; to Italy, 2583 cases: gross weight, 319,829 lb. avoirdupois: in 1870, France, 3900; and Italy, 2309.

ESTIMATE OF 1869.

	Cards.
The gross weight for 100 cards being found to be 23 lb. on average, 319,829 lb. give a total export of	1,390,500
Or an average number of 220 cards per case.	
The returns of the Custom House for export duty paid give a total of	1,360,000
The daily returns for arrivals, settlements, and stocks, from June 28 to December 1, result in total settlements of	1,420,000

The following may be considered reliable on the subject of cocoon:

1 card Japanese should produce 40 kilos. of fresh cocoons.
1 card equals 23 to 24 drachms of seed.
15 kilos. of fresh Japan cocoons = 1 kilo. of silk.
4 " dried " = 1 "
1 card should *produce* 2 kilos. per 100 drachms of silk, which, *at the value of 120* frs. per kilo., equals 13*l*. sterling.

The result of the disease in Italy is shown by the following Tables, calculated for bales of 102 lb. weight:

Average production prior to the disease, 81·600.

1863 ..	..	Bales, 50·600	..	Deficit,	38	per cent.
1864 ..	..	„ 38·000	..	„	53	„
1865 ..	..	„ 38·700	..	„	52	„
1866 ..	..	„ 39·600	..	„	51	„
1867 ..	..	„ 44·000	..	„	46	„
1868 ..	..	„ 41·000	..	„	49	„
1869 ..	..	„ 47·300	..	„	42	„
1870 ..	..	„ 69·900	..	„	14	„
1871 ..	..	„ 76·300	..	„	6	„
1872 ..	..	„ 68·000	..	„	16	„

Calculations having reference to the rearing of silk-worms are usually understood to apply to one ounce of "graine" or eggs. For example, the following Tables, compiled to show the weight of mulberry leaf consumed, and the space required in square feet during the different stages through which the worm passes, are all thus calculated:

Age.	Days.	Space required.	Weight of Clean Leaves consumed.
		sq. ft.	lb.
1st	5	9½	6
2nd	4	14½	22
3rd	6	46	65
4th	7	109	200
5th	9	240	1200
	31	..	1493

Thus from the hatching of 1 oz., the worms produced consumed during thirty-one or thirty-two days about 1500 lb. weight of leaves.

By the open-air process, now so much adopted by the rearers of M. Roland's regenerated races, the length of time required for the rearing is less easily calculated, cold weather retarding the progress of the worm, which may be protracted to forty days without injury to the cocoon.

At the end of the last stage the worm "mounts," that is to say, ceases to feed, climbs up from the feeding tray to the "bush," "echellette," or whatever may have been prepared for it, and spins its cocoon.

This in many countries completes the operation of the rearers, for up to this point it is frequently a sort of partnership arrangement; as for instance, in Italy the owner of the soil supplies the silkworm eggs and the mulberry leaf to the cultivator, the latter gathering the leaf and providing all the labour for rearing. The cultivator takes half the produce for his share, and the owner the other half; but the cultivator gives back one-fifth, so that, in reality, the owner takes six-tenths and the cultivator four-tenths.

The proprietor generally hatches the eggs, and when they are two days old, distributes them in various proportions among the cultivators, each taking his allotted portion to his home.

The cocoons are then gathered from the "bush," and sent to the market in large baskets, or valued and taken by the proprietor, if he happens to be the owner of a filature as well.

The next *process* is that of stifling or destroying the vitality of the chrysalis, by dry heat, or by the more modern application of steam, a method invented by Professor Castrogiovanni, of Turin. It consists in submitting the cocoons to a steam bath, at an uniform temperature of 100° centigrade. The steam rising practically uncondensed, under an iron receiver, which covers the cocoons, the chrysalids are suffocated by the diffused heat, which penetrates thoroughly, while the web of the cocoon retains its natural condition.

The principal requirements are three:

1. A basin with a furnace underneath, or, if more convenient, made to communicate by a pipe with a steam boiler.

2. Two circular plates, running on rails, on which the trays with the cocoons are placed.

3. A bell receiver, supported by two iron uprights, and easily raised or lowered by means of a pulley and counterpoise.

The bell is provided with a thermometer and a stop-cock, for letting off the air and steam when required.

The apparatus is thus used:

When the basin has been partly filled with water, to the height of 10 centimetres, the furnace fire is lighted, and the bell lowered, the stop-cock being open. As soon as the thermometer registers 99° or 100° centigrade the cock is shut, not to be opened again during the operations. The bell is next raised, to permit the plate on which the trays of cocoons are placed to be run over the basin, and then lowered again into the water, until its edges are covered, but not so as to *touch the* bottom of the basin.

In about fifteen minutes the bell is lifted, the cocoons which have been steamed are run off, and the second batch, which has been made ready in the meantime, takes the place of the first.

For the full success of the operation the water must always be boiling, the fire well kept up, and the internal temperature of the receiver maintained at the same degree.

The cocoon may be considered the raw material of silk, and as such it is recognized almost everywhere but in this country. In other manufacturing places of any note, the selection of cocoons and the reeling, which is the first process of manufacture, attracts a very considerable attention, as too important an element in careful manipulation to be neglected.

It might be supposed that cocoons do not come to this country at all, but it is not so. In 1869, before political events deranged the trade of France, we find that there were exported from England to France more than 100,000 kilos. of cocoons, valued at nearly two and a-half million francs, though it is quite probable that a portion of this, after passing through the first process of reeling, found its way back to this country in the form of "raw silk."

The art of reeling silk from the cocoons is very simple, and it is strange that it has never been introduced into this country.

The ordinary reeling machine consists of a reel measuring in circumference from 60 to 80 inches, the framework containing the guides, the basins, and the means of heating the water in them. In the East the native reeler frequently turns the reel as well as tends the basin, but in modern filatures not only is the reel turned by steam, but an attendant prepares the cocoons, and has the end formed ready for the reeler.

The cocoons, stripped of the surrounding floss, are placed conveniently beside the reeler, who, taking a handful, puts them in the basin containing hot water, and by watching them, soon ascertains if the water be hot enough or otherwise. If, as the reel carries off the thread, the cocoon lifts from the basin, the water is not hot enough to dissolve the natural gum of the cocoon with sufficient rapidity; if, on the other hand, the silk comes from the cocoon in flakes, the water is too hot.

In large filatures this is regulated by turning on or shutting off a jet of steam which is under the control of the reeler, and in China or Japan by regulating the charcoal fires under the basins. Having beaten the cocoons in the water with a small birch whisk, until the remaining floss is got rid of, and the true thread is drawn from the cocoon, the reeler then seizes as many single filaments as she proposes to make into a thread, and rapidly passes them through the first guide. Again drawing the filaments from another equal number of cocoons, she repeats the operation with another guide. There are now two threads drawn from equal numbers of cocoons, above the first guides; these are twisted together so as to form for a short space the strands, as it were, of a two-cord thread, leaving the twist or "croissage" intact. The threads again diverge, and passing through the second fixed guides, and thence *through* the distributing guides, are attached to the reel. The object of this croissage is to deliver on to the reel a round thread, and but for it the thread in its soft condition would, in passing the guides, not only assume a flat shape, but acquire an undesirable amount of roughness as well.

The intelligence of the reeler is now called into request, for to maintain the silk thread the same size requires the utmost skill and care. Supposing the reeler to start with six cocoons to a thread, the filament of each of these cocoons becomes more and more attenuated as it approaches the centre or skein covering the chrysalis; and to be able to calculate the additional cocoons required to compensate for this attenuation constitutes the great art of reeling, and prevents its ever becoming a mechanical process. The six cocoons with which the reeler started with are increased at times to nine, and yet the thread is no thicker as it reaches the reel, than at the commencement, when only six cocoons were used.

The skein of silk upon the reel is the "raw" silk of commerce, and it is determined to a great extent by its fineness and regularity of thread, its clearness or freedom from knibs or particles of skin and badly attached filaments. Its fineness is not entirely judged by the eye, but by weighing a given length, generally 400 revolutions of a reel made for the purpose, the weight being expressed by a technical weight termed "denier," 200 of which are equal to 16½ grains. The number of deniers is called the title of the silk, and accompanies the quotations of the higher classes, especially of thrown silks.

Another more complicated method of reeling silk was patented in this country some twenty-five years ago, and has since been adopted by the Chevalier Keller at Milan, under whose skill and auspices the perfection of silk reeling is now being carried out. This is a slow process, which not only allows the thread to dry, but passes it on from the distributing guides to the throwing machinery, which at once puts the first twist into the threads and delivers it on to a bobbin in the form of "singles." It is this process which would appear to be so admirably adapted to the available labour of this country.

The increase in consumption of raw silk is shown in the following figures:

SILK PASSED THE CONDITIONING AT LYONS.

	kilos.
1807	362,557
1824	634,702
1834	1,375,387
1854	2,375 889
1864	3,508,632

Each of the above amounts is the mean of ten years.

EXPORTS FROM FRANCE.

	kilos.
1827 to 1836	121,400,000
1836 " 1845	134,700,000
1847 " 1856	274,700,000
1857 " 1866	414,000,000
1867 " 1872	465,000,000

The bulk of these exports were from Lyons, *St.* Etienne, and Tours.

The values have risen as follows:

	Millions of Francs.				
	1852.	1862.	1867.	1871.	1873.
Plain silks	142	193	294	324	308
Brocades (*façonners*)	39	30	9	4	2
Mixtures	49	60	18	16	17
Ribbons	117	47	61	111	110
Fancy articles	11	33	40	42	52
	358	363	422	497	489

The above Tables, compiled from official sources, convey the best idea of the magnitude of this industry in France.

The form in which raw silk is usually imported into this country to be sold to our manufacturers, is in "books," or bundles, packed in bales. The most of these come from China, Japan, and India.

From the two former places were exported in the seasons:

	Bales.
From 1845 to 1846	18,600
„ 1850 „ 1851	22,144
„ 1853 „ 1854	61,283
„ 1855 „ 1856	50,481
„ 1857 „ 1858	68,315
„ 1858 „ 1859	83,134
„ 1859 „ 1860	64,169
„ 1860 „ 1861	70,644
„ 1861 „ 1862	79,199
„ 1862 „ 1863	72,887
„ 1863 „ 1864	46,603

	Bales.
From 1864 to 1865	32,313
" 1865 " 1866	62,890
" 1866 " 1867	50,052
" 1867 " 1868	57,449
" 1868 " 1869	70,917
" 1869 " 1870	63,807
" 1870 " 1871	51,329
" 1871 " 1872	54,589
" 1872 " 1873	57,263

These bales are of the weight of 102 lb. to 103 lb. each, and may, for the purpose of rough calculations, be estimated at 100 lb. per bale.

From India the average annual exports in pounds have been :

	Average lb.
From 1839 to 1842	1,384,240
" 1843 " 1846	1,555,130
" 1847 " 1851	1,290,020
" 1852 " 1856	1,511,768
" 1857 " 1861	1,511,770
" 1862 " 1866	1,485,760
" 1867 " 1871	1,558,250

Before the raw silk reaches the loom, it passes through five processes besides the boiling or dyeing, and these manipulations may be thus briefly described.

The first is the transferring the silk from the irregularly lengthed skeins * to the bobbins. The skein being stretched upon the "swift," or light revolving frame for holding it, the thread passes through the

* Skeins of silk vary in length from 60 to 90 inches, and in some instances more than this: 72 inches being the more useful *length.*

traversing guide, on to the bobbin, rotating on a horizontal axis, motion being communicated to the bobbin by a little wooden roller on the bobbin spindle. This spindle, placed in two grooves, is parallel to a light shaft bearing at one end a metal wheel, the friction of which, conveyed by the little roller, gives motion to the bobbins. A face cam gives motion to the traversing guides, calculated according to the length of the bobbin.

The second process, viz. cleaning, simply transfers the silk from one bobbin to another, though in the transfer it passes through the cleaner, which is composed of two fixed parallel plates placed so close to one another, that any knot or irregularity upon the silk is caught and the motion arrested until the attendant removes the cause. So nicely are these plates frequently adjusted, that an increased size in the thread from bad reeling stops the machine, and the bobbin is replaced with more regular silk.

The third process is doubling. By the doubling machine the single threads from two bobbins are brought side by side on to one bobbin, but without any twist. The fourth or spinning machine puts a spin or twist into either a single thread or the two, which the third machine brought together. The fifth or spinning machine resolves the silk into the specific terms "tram" and "organzine."

Silk throwing is the technical, but vague, term used to include the various processes of winding, twisting, doubling, and retwisting raw silk.

"*Singles,*" *without* twist, is employed for such round the coarser thread, which is invariably the shorter of the two, and can therefore the better sustain any excessive strain to which the doubled thread may be subjected. The cording of threads doubled and twisted together in one operation is more perfect, than when the process is accomplished in two operations.

To the throwing machine exhibited at the Exhibition was attached one of the maker's patented self-acting count guider and stop motion. This motion registers in yards the exact length of each skein; and when one skein of the length required has been run to, it moves the guider, and alongside of the first skein runs another of the same length, until the reel is full, when it stops the machine, and secures perfect uniformity in length of skein or hank. These are afterwards weighed on deniering machines, and, as the skeins are all of one length, the weight denotes as nearly as possible the correct size of the silk.

The next process which the silk undergoes is that of boiling and dyeing. The raw silk, as it reaches the dyer, contains the natural gum and colour from the worm, with soap and other impurities, some of which have been necessarily added in "throwing" it, and which have all to be discharged from "soft" silks, though in the case of other silks this is less fully done. The silk is therefore placed in hanks on long sticks, immersed in a boiling liquor of soap, water, and carbonate of soda, "turned" from twenty to forty minutes, "crushed," or squeezed, put upon cords, placed in bags, steeped for two or three hours in almost boiling soap and water, which the fabric of the bags allows to pass freely through it, taken out, washed in cold water to free it from the soap; and, this done, it is ready for the dyeing "barques." For white and other delicate shades, however, it is bleached before the dyeing in an air-tight room in which sulphur is burnt.

White is a combination of red and blue, and formerly the red was given by orchil or cochineal, and the blue by indigo. Aniline is now used for both; but the colour, though much finer, is not so lasting. The alcoholic solution of the colour is diluted with hot water and soap, through which the silk is passed, and it is afterwards passed through water acidulated with tartaric acid. (Great difficulty is found in producing pure white when the natural colour of the material is brown.) The silk is placed in hanks upon sticks which rest on the edges of the dyeing barques, the silk hanging down and immersed about three-fourths in the dye. It is then "turned" or "pulled over," to bring the remainder in contact with the solution. When the workman considers that the colour of the silk resembles the pattern which he has to copy, he takes a little, dries and compares it. If it is not quite a match, he adds to the dye such colouring matter as he thinks necessary; in some cases he has to do this frequently.

There are several descriptions of pinks, known in the trade as Safflower, Magenta, and Magdala. The first is procured from the flower of *Carthamus tinctorius*, a plant of Northern India, somewhat resembling a thistle, but of a red hue, and containing two colouring matters, red and yellow, the red only being of use to the dyer, to whom it is supplied as carthamine, or carminic acid.

The magenta pink is procured from aniline, by the action of various reagents, the most valuable kind being derived from combination with arsenic acid. Magdala pink is a very beautiful colour, giving a kind of chameleon shade with direct and reflected light. It is prepared from napthaline, and is very variable in its results.

Such colours as leghorn, straw, maize, &c., were formerly produced by a combination of anatto with other colouring matters; brown and claret by a union of various vegetable dyes—fustic, brazil, logwood, indigo, &c. All these are now dyed with the products of coal-tar in various degrees of combination.

Scarlet and crimson are among the series that formerly derived their colour from the animal kingdom, and as the export of cochineal from Mexico became lessened, these dyes became more and more costly. Rosaline, magenta, and the other coal-tar colours have now to a great extent superseded the use of this expensive dye.

The old celebrated Coventry blue was obtained from indigo produced by plants of the genus *Indigoferre*, cultivated in various parts of the world, especially in India. Another blue, the Napoleon, was made by salt of iron and potash, a modification of Prussian blue. The splendid blues now produced have their origin in the indefatigable labours of Mr. Nicholson, who first manufactured magenta on a large scale, and who has since produced the whole series of colours, running from magenta or roseine, to red violet, violet, violet blue, and the most pure opal blue. Lavender, silver, and harmaline are produced by the judicious combination of aniline blue and violet.

The violet obtained from aniline eclipses anything we can imagine to have been produced by the Tyrians in their celebrated purple.

A good substantial green was formerly dyed by a mixture of indigo blue and fustic; but it was impossible by artificial light to distinguish from a blue the green so obtained. The first "gaslight" green was that derived from a colour produced by the action of aldehyde upon roseine, the yellow of picric acid being used to increase the yellowness of shade. It is said that the Chinese produce a "gaslight" green from chlorophyl, the colouring matter of leaves.

During the processes of "taking off" and "boiling," silk loses at least a quarter of its original weight. Formerly, in the case of black silk, manufacturers were willing to allow the dyer to employ a dye, which caused him to return them the material with a loss of this weight; or at most they only required him to send it back at the weight at which he received it. But for some years they have required it to be made heavier, and the weighting has more recently very much increased. In silks for ribbons and broad silks double weight is often thus given; in silks used in the manufacture of fringes, four times the original weight, and in case of certain silks exhibited at the Silk Exhibition of 1873, six times the natural weight had been attained. Ordinary unweighted black is dyed by the use of a salt of iron and logwood; but for the weighted silks, a quantity of iron, gambier, chestnut, or some wood containing a large amount of tannin, is employed. Manchester and Derby in this country, Crefeld in Germany, and Lyons in France, are much noted for the beauty of their heavy blacks. It has been found that a very large quantity of water is necessary for cleansing the silk in weighted black dyeing; and in each town where this branch of the trade is carried on, water is supplied by rivers, or collected in large reservoirs from the surrounding hills. In Lyons, Basle, and Derby, the workmen wash out their silk in flat-bottomed boats.

The black dresses of our grandmothers were often, after years of wear, handed down to their children and grandchildren. Now that the weighted silks are employed, great complaints are made by the ladies that their dresses are worn out so rapidly; but on the other hand, one effect of the weighting is to make the thread of silk cover twice the space it formerly did, and by these means produce a corresponding reduction in the cost of a given length.

All silks after the various processes of dyeing are dried in a stove heated by hot air, or steam, and then "stringed," an operation which gives them increased lustre. In some cases they are stretched on revolving heated rollers.

The Manchester Wool and Silk Conditioning Company have issued a statement of the results of conditioning for moisture and boiling off silk for gum, soap, &c., from 1st May, 1870, to 30th April, 1871. A comparative statement of silk conditioning by the Company from 1866 to 1871 gives the following figures:

CHINA—ORGAN, TRAM, AND RAW.

	Gross weight received.	Conditioned weight returned.	Average loss per cent. in moisture.
	lb.	lb.	per cent.
1866 and 1867	7,303· 3	7,146·10	1·95
1867 „ 1868	11,324· 8	11,141·13	1·53
1868 „ 1869	16,239· 4	15,876· 6	1·54
1869 „ 1870	19,039· 9	18,707·14	1·58
1870 „ 1871	15,339·13	14,944· 6	1·82
JAPAN—ORGAN, TRAM, AND RAW.			
1866 and 1867	3,156· 3	3,065· 8	2·44
1867 „ 1868	2,778·10	2,655· 8	1·90
1868 „ 1869	6,460· 5	6,213· 6	2·04
1869 „ 1870	2,970·14	2,836·11	2·52
1870 „ 1871	3,268·10	3,147· 7	2·43
ITALIAN—ORGAN, TRAM, AND RAW.			
1866 and 1867	14,721·14	14,027·14	1·74
1867 „ 1868	9,363·11	1,957· 6	2·00
1868 „ 1869	3,710· 1	3,545· 7	2·04
1869 „ 1870	6,204·15	5,951·14	1·58
1870 „ 1871	15,745· 5	15,120·11	1·65

In 1872 the manufactures of Lyons occupied 120,000 looms, of which 30,000 were in the city, and 90,000 in the neighbouring departments.

These 120,000 looms consume annually 2,200,000 kilograms of silk, and produce goods valued at 460 millions of francs, of which 350 millions are exported, and 110 millions consumed in the country.

The most important of these manufactures comprise:

	Millions francs.
Foulards	50
Crapes	8
Tulles, plain and coloured	14
Velvets, silk and mixtures	30
Satins	25
Taffetas and "failles," black	165
Ditto, coloured	120
Other plain thin goods	10
Brocades for dress	8
Ditto for furniture	10
Sundry mixed tissues	20

For the material of this enormous production France is indebted (taking the average of a series of years):

To China, Japan, and Bengal	for 40	per cent.
" Italy	" 22	"
" Broussa, Persia, and the Levant	" 8	"
And raised in France	30	"

Thus France is largely indebted to foreign countries for her supplies, and, in fact, since the epidemic the indigenous production has fallen off considerably.

From 1845 to 1854 France produced an annual average of seventeen million kilograms of cocoons. In 1853 she reached the highest figure of twenty millions. Then came the disease, and the production fell to:

	kilos.
In 1855	12,000,000
" 1856 to '60	10,000,000
" 1861 to '65	8,000,000
" 1865	5,500,000

During the following years the production in France has been eight to ten millions of kilos. In 1872 it was

9,871,000 kilos. of cocoons, which gave about 636,800 kilos. of silk.

The receipts of cocoons at Marseilles for the past four years have been as follows:

	kilos.		kilos.
1870	376,390	1872	1,079,000
1871	1,017,550	1873	1,128,800

According to reliable authorities, the present production of silk in Europe may be computed at:

	1872.	1873.
	kilos.	kilos.
In Italy	3,125,000	2,700,000
„ France	636,800	475,000
„ Spain	171,400	105,000
„ Levant	334,600	396,000
Total kilos.	4,267,800	3,676,000

The following Tables will be found interesting, inasmuch as the European silks have been made to correspond to the China bales, reckoning 45 kilos. as equalling 1 bale:

TABLE SHOWING THE QUANTITY OF SILK CONSUMED IN EUROPE IN BALES UPON THE BASIS OF 1 BALE = 45 KILOS.

Seasons.	1866–7.	1867–8.	1868–9.	1869–70.	1870–1.	1871–2.	1872–3.
Europe	100,000	100,000	110,000	115,000	110,000	130,000	100,000
Chinas	28,500	41,300	46,600	42,800	33,600	46,400	55,000
Japans	14,400	11,700	14,800	14,000	8,300	14,600	12,500
Cantons	4,400	4,000	6,800	7,200	10,800	13,400	16,000
Total bales ..	147,300	157,000	178,200	179,000	162,700	204,440	183,500

TABLE SHOWING THE PRODUCTION OF SILK IN BALES EXCLUSIVE OF THE PRINCIPAL ASIATIC SILKS.

Italy, Kilos. 3,125,000 = Bales	68,000
France „ 636,800 = „	13,370
Spain	3,500
Brutia	1,700
Salonica	732
Syria	12,800
Greece	140
Georgia, Nouka, and Persia	2,420
Bales	91,142

FRENCH IMPORTS AND EXPORTS OF SILK GOODS AND SILK.

	1869.	1870.	1871.	1872.	1873.
IMPORTS.	frs.	frs.	frs.	frs.	frs.
Silk and Cocoons ..	411,772,000	307,532,000	415,564,000	418,329,000	375,818,000
Silk Goods	28,048,000	28,015,000	47,643,000	37,522,000	31,200,000
EXPORTS.					
Silk and Cocoons ..	156,122,000	194,795,000	104,402,000	132,498,000	104,466,000
Silk Goods	447,339,000	524,508,000	496,616,000	487,994,000	524,728,000

TABLE SHOWING THE PRICES OF CHINAS COMPARED WITH ITALIAN RAWS, REDUCED TO ENGLISH LBS. AND SHILLINGS.

	Tsatlees.		Taysaams.		Cantons.		Japans.	Italian Raws.
	s. d.	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s.*
1835 ..	19 0 to	21 0	17 0 to	17 6	..		..	24
1840 ..	22 6	25 0	none.		..		..	23
1845 ..	20 0	21 0	none.		10 0	11 0	..	23
1850 ..	14 0	19 0	12 0	13 6	..		..	21
1855 ..	14 0	18 6	11 0	12 0	8 0	12 0	..	21
1856 ..	15 0	19 6	11 0	15 6	8 0	12 0	..	27
1857 ..	24 6	27 0	19 0	23 6	13 0	19 6	..	39
1858 ..	15 0	18 6	10 6	15 0	9 0	14 0	..	29
1860 ..	21 0	26 6	18 6	21 6	13 0	18 0	..	40
1862 ..	16 6	22 0	12 0	17 0	9 0	15 0	25 0	28
1865 ..	23 0	27 0	20 0	24 6	18 0	22 0	28 6	32
1867 ..	26 0	34 0	21 0	28 0	21 0	24 6	36 0	40
1870 ..	21 6	32 0	19 0	25 0	17 0	22 6	32 0	37
1871 ..	23 6	31 0	18 0	27 0	12 0	19 0	28 6	35
1873 ..	14 6	22 6	12 6	17 6	13 0	16 0	23 6	35

TABLE SHOWING THE PRODUCTION OF SILK CONSUMED IN EUROPE DURING THE YEARS OF THE DISEASE, IN THE EQUIVALENT OF CHINA BALES AT 45 KILOS. PER BALE.

	1854.	1855.	1856.	1857.	1858.	1859.	1860.	1861.	1862.	1863.	1864.	1865.
EUROPE—												
Italy	92,400	80,300	57,200	55,000	49,500	40,700	57,750	50,600	48,400	48,400	46,200	44,000
France	44,000	39,600	19,800	19,800	26,400	28,600	33,000	33,000	30,800	39,600	28,600	17,600
Spain	3,300	2,200	1,100	2,200	3,300	4,400	4,400	3,300	3,300	4,400	2,200	2,200
Turkey in Europe, Greece, and Caucasus	6,600	5,500	4,400	5,500	5,500	5,500	6,050	6,600	8,800	6,600	8,800	4,400
Total	146,300	127,600	82,500	82,500	84,700	79,200	101,200	93,500	91,300	99,000	85,800	68,200

IMPORTATIONS INTO EUROPE.

	1854.	1855.	1856.	1857.	1858.	1859.	1860.	1861.	1862.	1863.	1864.	1865.
ASIA—												
China	55,000	63,800	101,200	68,200	86,900	70,400	92,400	83,600	74,800	61,600	33,000	50,600
Japan	..	..	..	..	..	..	..	13,200	11,000	30,800	19,800	17,600
Bengal	11,000	15,400	15,400	13,200	11,000	11,000	11,000	13,200	13,200	13,200	15,400	13,200
Turkey in Asia, and Persia	19,800	15,400	19,800	17,600	17,600	17,600	17,600	17,600	19,800	19,800	22,000	22,000
Total	85,800	94,600	136,400	99,060	115,500	99,000	121,000	127,600	118,800	125,400	90,200	103,400
Grand Total ..	232,100	222,200	218,900	181,500	200,200	178,200	222,200	221,100	210,100	224,400	176,000	171,600
Prices of cocoons in France during same periods in francs and cents	4·65	4·85	7·90	8·10	5·50	7·12½	7·25	6·25	5·60	5·	6·25	8·

COMPARATIVE PRICES OF SILK AT LYONS ON THE 31ST DECEMBER OF THE LAST FOURTEEN YEARS.

	1860.	1861.	1862.	1863.	1864.	1865.	1866.	1867.	1868.	1869.	1870.	1871.	1872.	1873.
ORGANZINES.														
France, fibre and work, 1st class, 22–28.. ..	116 118	95 98	98 101	90 93	107 110	123 126	123 128	132 135	150 152	133 135	99 105	120 124	124 126	108 112
Ditto, work, 22–28 ..	100 105	76 81	87 90	79 83	95 99	116 120	118 121	116 121	120 135	110 114	93 103	115 118	115 120	100 103
Piedmont, fibre and work, 1st class, 22–28	104 109	81 86	91 97	80 84	99 104	120 125	118 123	122 130	145 151	123 128	96 106	116 122	116 124	102 106
Italy, 2nd class, 22–28 ..	88 92	66 74	79 85	70 77	90 95	111 114	111 114	118 122	126 132	100 110	83 96	98 105	109 112	90 96
TRAMS.														
France, fibre and work, 1st and 2nd class, 22-28	109 116	84 94	91 95	84 88	99 104	117 123	117 123	123 127	136 148	120 129	98 103	112 115	112 122	98 106
Italy, 2nd class, 26–28..	84 88	62 69	77 82	68 70	88 92	102 107	99 106	97 105	106 114	98 118	85 95	96 104	98 106	86 94
China, French work, 40–45	76 79	62 66	74 78	74 78	84 86	95 99	106 110	92 96	84 93	88 96	80 90	92 100	85 94	68 75
Italy, 1st and 2nd class, 11–13	82 84	58 63	74 77	62 68	83 87	100 106	92 101	92 102	100 118	80 110	74 88	85 105	92 106	80 90
RAWS.														
Tsatlee, 3rd class	65 67	52 55	63 66	63 66	73 76	87 90	90 91	79 82	78 82	82 85	79 81	80 83	79 81	64 66
Kahing, Nos. 2 and 3 ..	56 60	40 44	53 55	57 63	69 71	76 79	76 82	64 69	60 65	62 67	57 65	62 72	60 66	44 48
Bengal, 1st class, 12–16	70 73	53 58	60 69	57 63	72 76	90 93	90 92	74 80	74 84	75 82	60 70	60 70	64 73	57 62
Mybash, No. 1, 10–16 ..	..	..	73 77	70 74	81 84	102 106	104 106	99 104	100 106	88 98	72 75	75 78	76 79	70 74
Oshio, extra, 14-22 ..	..	..	..	65 67	..	93 94	94 106	84 88	98 101	100 103	83 85	86 89	81 83	68 72

Tussahs.—The silks now generally recognized as tussahs, and already mentioned as produced principally in China and India, are a description of wild silk, hitherto neglected by Europeans, but now deservedly attracting much notice. In the East they have been long appreciated, from their cheapness and durability.

The Sze-Chuen and Shan-tung silk piece goods, which are true "tussahs," have for years past been largely exported to India, America, and other places; and now that fashion has produced a demand, it is found that wild silk is to be obtained from many places where least expected. It is more than probable that in all tropical and subtropical countries some kind of wild silk may be found. The methods now applied of treating the cocoons with hot alkaline solutions, to dissolve the gum and set free the silk, thus producing a condition in which it can be carded and spun, will doubtless cause supplies from many countries hitherto unnoticed.

First among the tussahs must be classed the Yama-mai of Japan, the more so for the reason that it is one of the few descriptions that can be reeled with any facility; for although some of the Indian tussahs are reeled by the natives, the process is so slow and laborious that it is hopeless to expect any large quantity of the reeled silk.

Mr. Consul Adams, in his report on the silk districts of Japan, gives the following history of the Yama-mai industry:

"It appears that there are sixteen villages, the inhabitants of which form an association called 'Matsu-kawa-gami,' and are entirely engaged in the culture of the Yama-mai; that this culture was first initiated about forty years ago, and since then had gradually taken greater dimensions, till the number of cocoons annually sold by the association alone is computed at not less than 20,000,000.

"Each rearer rears from 100,000 to 200,000, and the price of a thousand is estimated at \$3 to \$3½. The best sort of silk is sold at \$800 per picul (133 lb.), and the inferior at about \$500. Close up to the Western range of hills are a number of plantations of the 'Kunogi,' which is by the rearers pronounced to be the best food for the Yama-mai. Its leaf is considered to be that of *Quercus serrata*. The worms can be fed on other varieties of oak leaves, but those of the 'Kunogi' alone are used in this district.

"The larvæ were mostly in the fourth and fifth stages, and it was a curious and most interesting sight to watch them clinging to the branches and leaf-stems, and to observe how completely their colour corresponded with the leaf on which they most delight to feed. Their bodies were of a pure and almost transparent green, with a bright line running down the sides, ending in a brown patch, the two quicksilver-like spots on each side being plainly visible. Diminutive blue spots were also to be seen at intervals along the body. So much did every colour and streak resemble the plants to which they clung, that it was long before our eyes became sufficiently practised to distinguish them *at all without* close examination.

"The length of time between hatching and spinning, during the whole of which the larvæ remain in the open air, passing through four periods of rest, is reckoned at about sixty days, more or less, according to the temperature. We were told that the first rest commenced on the seventh day, and continued for two days; that the succeeding three periods of activity and torpor were severally longer than the first, and that the spinning commenced about ten or eleven days after the fourth rest."

Specimens of this silk exhibited at the International Exhibition of 1873 bore a value of 27*s.* per lb., which tends to confirm Mr. Adams' values as given above.

The varieties of tussahs in China are at present but little known. Mr. Consul Meadows reports fully upon the Mountain silk of Newchwang, Mr. Vice-Consul Alabaster on the Ailanthus silk of Chefoo, both of which districts were formerly supposed to be too far north, and consequently too cold to rear any description of silk, but in the western provinces the tussahs abound, and the brown rough silk garments worn by the natives prove its large production and consumption in the country.

In India the reports compiled by the Government give particulars of no less than thirty-six varieties feeding upon different forest trees and shrubs. Chief among these may be mentioned the *Antheræa paphia*, found in the jungles all over India.

Antheræa Perui, an oak-feeder.

Antheræa Assami, described as "a very excellent silk."

Attacus Atlas, the largest of the silk producers.

Attacus Cynthia, the Ailanthus worm, now being reared in Europe, America, and Australia.

Attacus Ricini, the castor-oil plant feeder of Assam, said to be easily reared and produce a good light-coloured silk.

The extent to which these tussah silks are used in India has been but little appreciated in this country, the consumption until the last year or two being confined to the natives.

Buchanan, speaking of Assam, states: "The native women of all castes weave the four kinds of silk that are produced in the country, and with which three-fourths of the people are clothed."

Hugen, in 1834, estimated the quantity of land planted in Assam with food for one description at 5000 acres; and Col. Hopkinson, Commissioner of Assam, states: "The Soou forests where one species of tussah is reared cover 34,000 acres, and the production of silk gives employment for the season to 48,000 persons. The produce is estimated at 100,000 lb. Nearly all this is consumed in the country."

In Bengal, Buchanan estimates the value of the tussah goods from three districts—Futwa, Gaya, and Nawada—at 3¼ lakhs of rupees (35,000*l.*), and of another district (Baulgulpon) at one lakh, per annum.

From the North-west, Central, and Southern India we find reports upon different descriptions of tussahs, generally utilized for native wear only. In Ceylon, the north end of the island abounds with the wild worm, the cocoons of which are not now gathered as formerly. It is probably not too much to say that in every forest or jungle district in India a tussah worm of some description may be found. Certain tussahs are indigenous to America, namely, *Cecropia*, *Promethea*, *Luna*, and *Polyphemus*; and in France the cultivation of the Yama-mai has for some time past attracted much attention. Its silk possesses the peculiar property of taking a different tint when placed in the same dye with that of the mulberry worm, which allows of the production of a curious variety of colour by simple immersion. The introduction of this worm gives a value to the leaves of the oak, which have not heretofore been turned to any commercial account.

Another worm which is largely cultivated in France is the *Bombyx cynthia*, which feeds on the ailanthe (*ailanthus*), and first received in error the name of the Japanese varnish tree, with which it has no relation.

The great stimulus given to the consumption of tussahs has been the invention of machinery for dressing, carding, and spinning these cocoons with waste and floss silks of a higher class.

The cocoons are first treated in strong alkaline solutions, which dissolve the gums and release the fibres from the lime-like secretions of the insect, after which the silk is boiled with soap until in a fit state for combing, carding, and spinning. The tussahs are now in the condition of any other prepared waste silk and subjected to the same processes, which are thus described in the report on the silk machinery of the Exhibition of 1873, in the 'Journal of the Society of Arts': "The *type* of the mechanism is that used in the cotton or wool manufacture, for when silk ceases to be a filament it becomes a fibrous material as cotton, and may be treated as such, subject to the consideration that the staple or length of each fibre is greater and more varied than that of cotton. The entangled fibres of the silk are reduced to lengths of about 8 inches, and to 'flakes' measuring about 8 inches by 3. These 'flakes' have been produced by a process of partial tearing, cutting, and careful combing, which lays the fibres parallel and enables an attendant to reduce them to suitable lengths. These are placed in baskets and taken to a machine called a spreader. They are then laid by hand one at a time upon an endless band, by which they are advanced until brought within the influence of a brass roller (porcupine roller) with fine teeth upon its surface. This roller delivers the fibres to a series of fine-toothed metal combs which are moving parallel to their length, and carrying with them the silk. By the action of these combs, and fluted rollers which receive the silk from the combs, the 'flakes' are not only further combed, but owing to the speed of the rollers being greater than that of the combs, the silken fibres are drawn forward elongated, the ends of one flake being, as it were, fitted over the ends of another, and one yard of these 'flakes' is extended to from 10 to 30 yards, according to the purpose for which the yarn will be required. The motion of the travelling combs is accomplished by the ends of the comb being carried on the grooves of two parallel square threaded screws, and passed from one set of parallel screws to a lower set by 'striking' cams, which cause their descent at one end; and, by a similar but reverse screw motion to the former, each comb is carried back and rises to the first position."

The combed and drawn silk fibres are conveyed by an endless band, in the form of a light flake-like ribbon, and coiled upon a large wooden wheel, from which an attendant takes off regular lengths and lays aside for the next process.

The next process is similar to that used for the finer wools and flax, converting the ribbon into a "sliver," and, as with the long wools, by the introduction of "screw gills" to support and regulate the fibre. The tussah in the form of spun silk is finally delivered on reels and is ready for the manufacturer. What beautiful fabrics may now be made from tussahs and waste silk thus treated was shown by the exhibits of manufactured spun silk in 1873, where it was proved to rival the more costly material in almost all useful articles. In fact, once reduced to the condition of a spun silk yarn, it is difficult to say to what useful purposes it may not be applied.

Hitherto there has been a difficulty in getting the Indian tussahs to take a dye, but this is now being successfully overcome, although there are certain delicate colours which they will never take.

Thus Dr. Sace, in speaking of the castor-oil silk, says: "One fact which diminishes the value of this silk is its brownish colour, which prevents its being used for clear colours. The fact disappears completely with the silk of the ailanthus worm, with which I will engage myself *to produce white* silk. That clever chemist and weaver, Monsieur de Jongh, finds that the gloss of the ailanthus silk far surpasses any of the other known kind of *bourre de soie.*"

But for the Jacquard loom the silk industry could never have attained its present dimensions, and although there is probably as much difference between the Stevens Coventry loom and the first Jacquard as between that and the old draw loom, still the improvements have been built from time to time upon the foundation of Jacquard's loom.

Within the last thirty years the Jacquard apparatus has undergone numerous modifications, not only to make it more efficient, but to adapt it to particular descriptions of weaving. It has also been successfully applied to the lace frame, and to several purposes apart from weaving, such as musical instruments, to punching machines for punching wrought-iron plates used in the construction of girders, and to type-setting machines. To increase the speed of the apparatus, and to make it more adapted to the power-loom, rising and falling motions have been given to the bottom board of the machine, as well as the griffe, and the double-action principle for increasing speed is gradually working its way. A great improvement has also been made by working the card cylinder by a connection which can be detached, which not only operates advantageously for the action of the griffe on the hooks, but enables the weaver to reverse the cards or "pull back" with ease and certainty.

Probably the best idea of the complication of movements of the most recent loom may be formed from the particulars of Stevens' loom in making a "Forester's" scarf two and a half yards long and six and a quarter inches wide, at the Industrial Exhibition. This scarf required the use of sixteen thousand perforated cards to make the figure and fourteen thousand for the plain part, making a total of thirty thousand cards. The number of threads in the warps of each scarf was one thousand eight hundred, and there were fifteen different colours in the shoots; these figures are multiplied by the number of pieces being made at once, so that with ten pieces making, eighteen thousand threads of warp would be in the loom. Hence the involved, and to the untrained eye inextricable, confusion of threads as shown in the harness of the loom.

It requires six months to fit up such a loom, and when it and the cards are all ready, it occupies a month to obtain one complete pattern. The cost of the loom with design and cards complete is about 500*l.*

The tests for silk are by burning and treatment with chemicals. Silk, if burnt, gives off the well-known smell of burnt horn.

Nitric acid turns it yellow, and dilute acids have little immediate action. Alkalies dissolve it, but as no sulphur is present, there is no formation of a sulphide, and the acetate of lead does not yield a black precipitate. Dilute alkalies affect it, but without solution. Ammonia has no action. In the cuprate of ammonia, an ammoniacal solution of copper sometimes known as Schweitzer's test, it dissolves like cotton. Its affinity for colours is like that of wool. To detect cotton, hemp, flax, and jute in mixture with wool and

N 2

silk, boil the sample in an aqueous solution of soda containing 10 per cent. of hydrate of soda. Wool and silk dissolve, while the vegetable fibres remain unacted upon. The whole is thrown upon a cotton filter, and the undissolved matter is then washed with hot water, and afterwards acidulated with 5 per cent. of hydrochloric acid, to which, if the residue is black or dark-coloured, a few drops of chlorine water are added. Meantime, the original alkaline filtrate can be tested for wool with the acetate of lead. If a white precipitate is formed, which dissolves on stirring, silk alone is present. A black precipitate indicates wool. The nitro-peroxide of sodium gives a violet colour if wool is present. If the tissue is deeply coloured, it may be cut up and steeped for fifteen to twenty minutes in a mixture of two measures of concentrated sulphuric and one of fuming nitric acid. Wool, silk, and colouring matters are destroyed, while the cellulose is converted into gun cotton. White and pale mixed tissues may be tested by their affinity for colours. They must be cleansed and rinsed thoroughly in water to remove starch and similar dressings; boiled for ten minutes in water containing 2 per cent. carbonate of soda and a little soap; then rinsed in hot water; steeped five to ten minutes in water at 50 to 60 deg. cent., containing 2 per cent. sulphuric acid, and washed again. In the meantime the colour-bath must be prepared by dissolving a few decigrammes of magenta in 28 to 30 cubic centimetres of water and heated to boiling; and during ebullition add to it, drop by drop, caustic soda till a pale rose colour only remains in the liquid; take off the fire, and put in the sample; after some minutes take out to dry. Silk and wool are dyed, while the vegetable fibres remain colourless. Wool may be detected in silk by the presence of sulphur; if it is immersed for a short time in plumbate of soda, the silk will be colourless and the wool black; or a piece of the tissue, two centimetres square, may be boiled in 10 to 12 cubic centimetres of Schweitzer's test; in from five to ten minutes the silk will be dissolved. If the silk is black, add double the volume of Schweitzer's test, and soak from ten to twelve minutes; after taking out the undissolved wool, the liquid, quickly neutralized with nitric acid, gives no precipitate if silk only is present, while cellulose is precipitated.

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* The authority for this says that he planted from 600 to 700.

† The same authority says that leaves may be gathered in the colonies at two years.

to be in Louisiana at 300 lb., all other States being less. Thus the comparative money values from an acre are :

300 lb. of cotton, at 1*s.*,	equal	15*l.* 0*s.*
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